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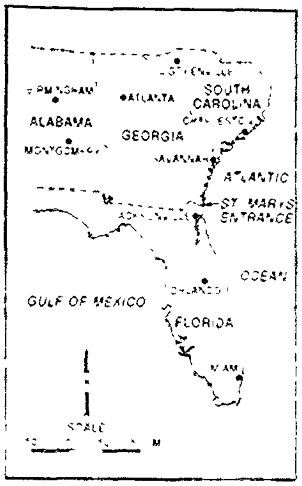

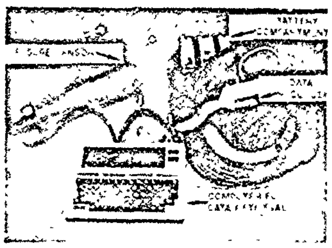

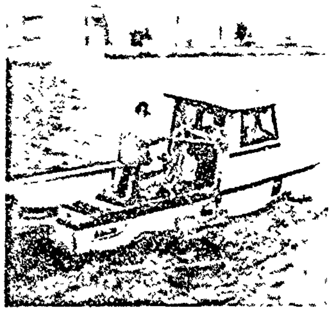

HYDRAULICS LABORATORY

TECHNICAL REPORT HL-91-4

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CUMBERLAND SOUND MONITORING

Report 1
1988 DATA COLLECTION REPORT

by

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Water levels, conductivity, temperature, and salinities were measured in the Cumberland Sound study area during March 1988 through December 1988. The data were collected as part of a long-term study to assess, through comparisons to earlier data collection programs, if changes to the estuarine processes of the study area have occurred. This report describes the equipment and procedures used in the data collection effort and presents tables and plots of representative data.

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PREFACE

The work described in this report was performed by the Hydraulics Laboratory (HL) of the US Army Engineer Waterways Experiment Station (WES) during March 1988 through December 1988 as a part of the overall Cumberland Sound Monitoring Program conducted for the Department of the Navy under the coordination of US Army Engineer Division, South Atlantic (SAD).

This study was conducted under the direction of Messrs. Frank A. Herrmann, Jr., Chief, HL; Richard A. Sager, Assistant Chief, HL; William H. McAnally, Jr., Chief, Estuaries Division (ED), HL; and George M. Fisackerly, Chief, Estuarine Processes Branch (EPB), ED. Ms. Joan Pope, Chief, Coastal Structures and Evaluation Branch, Coastal Engineering Research Center (CERC), served as the central point of contact for the entire monitoring effort at WES. Technical direction and guidance during the study were provided by Messrs. Albert G. Green, Jr., National Park Service (NPS), Thomas J. Peeling, Naval Facilities Engineering Command (NAVFACENGCOM), John Headland, NAVFACENGCOM, Darryl Molzan, NAVFACENGCOM, William Odum, University of Virginia, Charlotte, VA, and Robert G. Dean, University of Florida, Gainesville, FL, as members of the Kings Bay Coastal and Estuaring Monitoring Program Technical Review Committee. This report was prepared by Messrs. Fisackerly and Timothy L. Fagerburg, Howard A. Benson, and Joseph W. Parman with assistance by Clay LaHatte and Mrs. Clara J. Coleman, all of EPB. The HL portion of the project study was managed by Mr. Fisackerly. The field data collection program was designed by Messrs. Fisackerly, A. M. Teeter, Benson, EPB, and M. A. Granat, Estuarine Engineering Branch, ED, and executed under the direction of Messrs. Fisackerly, Fagerburg, and Benson. Other EPB personnel participating in the data collection were Messrs. Samuel E. Varnell, Billy G. Moore, Julian M. Savage, Thad C. Pratt, and Larry G. Caviness. Editing was performed by Mrs. Marsha C. Gay, Information Technology Laboratory, WES.

Commander and Director of WES during the preparation of this report was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
degrees Fahrenheit	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
inches	2.540	centimetres
miles (US nautical)	1.852	kilometres
square miles	2.589998	square kilometres

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* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

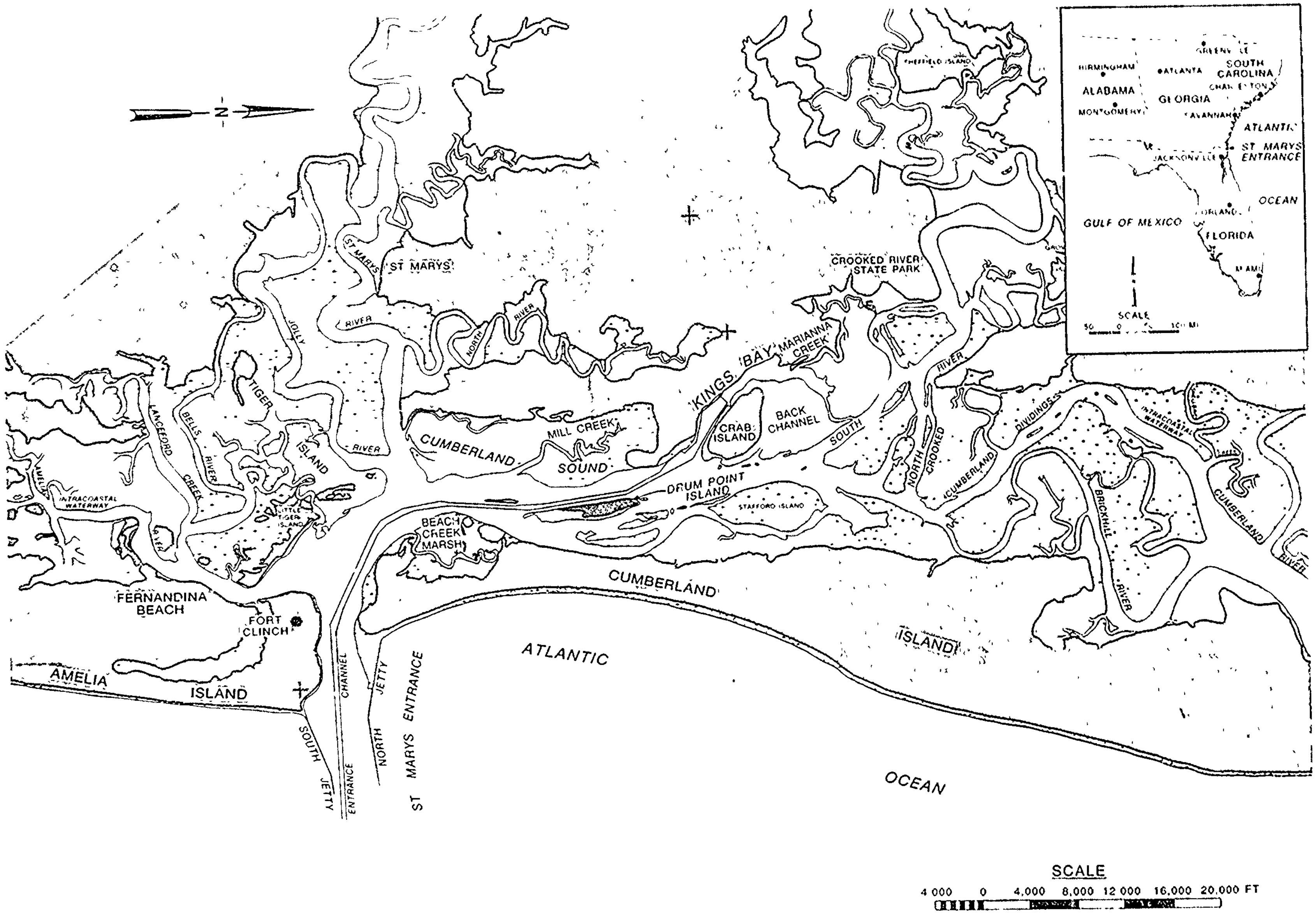

Figure 1. Cumberland Sound and Kings Bay vicinity map

CUMBERLAND SOUND MONITORING

1988 DATA COLLECTION REPORT

PART I: INTRODUCTION

Background

1. The original Kings Bay facility, located adjacent to Cumberland Sound in southeast Georgia, was designed and developed as an emergency Army Munitions Operation Transportation facility in the late 1950's. Initial channel depths were authorized at 32 ft* mean low water.** The facility was never placed into operational use and was in a standby mobilization status with channel depths of about 32 ft. Figure 1 shows the general Cumberland Sound and Kings Bay area.

2. In July 1978, ownership of the Kings Bay facility was transferred to the Department of the Navy for use as a Naval submarine base for Poseidon class submarines. Between July 1978 and July 1979, approximately 8.6 million cubic yards of material were removed for Poseidon facility expansion. Major channel realignment, widening, and deepening were performed. The lower entrance channels were authorized at depths of 38 to 40 ft and a width of 400 ft. The remaining interior approach channels were authorized at a depth of 34 ft and a width of 300 ft. Kings Bay was authorized at a depth of 37 ft. The total length of the interior Poseidon channel, from the throat of St. Marys entrance adjacent to Fort Clinch to the end of the main docking facility, was about 7 nautical miles (n.m.). The channel width widened from about 650 ft at the entrance to about 1,200 ft at the downstream end of the main docking facility.

3. The most recent changes to the channel, to accommodate the Trident submarines, included widening the approach channel to 500 ft and deepening it to 46 ft; deepening the ocean entrance channel to 49 ft; deepening Kings Bay

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* A table of factors for converting non-SI units of measurement to SI (metric) units is found on page 3.

** All depths and elevations (el) described in this report refer to local mean low water (mlw), which is 2.75 ft below National Geodetic Vertical Datum (NGVD).

to 48 ft; some additional widening within Kings Bay and at some of the lower channel bends; relocating the Poseidon tender from perpendicular to the channel to parallel to the channel above the floating dry dock; extending Kings Bay another nautical mile to the northwest to include a small boat facility, a Trident dry dock, and an upper turning basin; and building a magnetic silencing facility adjacent to the submarine channel across from Drum Point Island.

4. The State of Florida raised concerns about the potential for adverse impacts to coastal processes on Amelia Island to the south. In addition, the Department of Interior (DOI) raised concerns about potential impacts to the Cumberland Island National Seashore to the north of St. Mary's Inlet. These concerns included both the ocean coast of Cumberland Island and the interior Cumberland Sound Estuary. Partly as a result of these concerns, a 5-year study (1988-1992) was established to assess the effects of the Trident project on the estuarine and coastal processes in the area of Cumberland and Amelia Islands and Cumberland Sound. The US Army Engineer Waterways Experiment Station (WES) Hydraulics Laboratory is responsible for the program's estuarine studies. These studies include some numerical and physical model testing, and long- and short-term field data collection to assess the potential effects on the hydrodynamics of the system, such as tidal effects, changes in salinity, and sedimentation. The Coastal Engineering Research Center (CERC), WES, is responsible for the coastal portions of the programs and provides the central point of contact for the entire King Bay monitoring effort of WES. The US Army Engineer Division, South Atlantic, serves as the lead agency for coordination between the US Army Corps of Engineers and the Navy. In addition to WES, other agencies involved in the overall monitoring program are the Navy, South Atlantic Division, DOI, the National Park Service, and the US Army Engineer Districts of Savannah and Jacksonville.

Purpose

5. The purpose of the Cumberland Sound estuarine monitoring program is to provide seasonal, long-term, continuous monitoring of tides, conductivity, and temperature at six stations throughout the system over the 5-year project. Over the duration of the project, the data are to be presented in a series of interim reports. A final report is to be prepared at the conclusion of the

project that compares the acquired data to those of 1982 and 1985. The purpose of this report is to present representative samples of the long-term data collected during the first year of the project.

Scope

6. This report presents representative results of the field data collection program in the Cumberland Sound system during March 1988 through December 1988. Measurements consisted of the following at six locations:

   a. Water level elevation.

   b. Salinity.

   c. Conductivity.

   d. Temperature.

7. This report describes the field investigation methods used to collect the data, shows representative results of the data reduction efforts, and describes the availability of the data for further use.

PART II: THE CUMBERLAND SOUND SYSTEM

8. The Naval Submarine Base, Kings Bay, is located in southeast Georgia, about 9.6 n.m. north of the St. Marys Inlet entrance jetties at the Atlantic Ocean. The base is within the Cumberland Sound estuarine system, which includes extensive salt marshes and sand flats (shaded areas in Figure 1) typical of the sea island system of southeast Georgia. The mean tidal range at the ocean entrance between Amelia Island, in the State of Florida, and Cumberland Island, in the State of Georgia, is 5.8 ft. Maximum spring tidal ranges can exceed 8.0 ft in the interior portions of the estuary.

9. The primary source of fresh water for the Cumberland Sound estuarine system is the St. Marys River. The river originates in the Okefenokee Swamp, approximately 120 n.m. upstream from Cumberland Sound, and enters the sound about 5.5 n.m. south of the Kings Bay entrance. The St. Marys drainage basin includes about 1,478 square miles of swampland and coastal plain. The long-term average freshwater discharge at the mouth of the river is about 1,500 cfs. Freshwater discharges as high as 18,000 cfs have been recorded. Suspended sediment loads within the St. Marys River are generally low.

10. The Crooked River, located approximately 2 n.m. north of Kings Bay, is the second largest contributor of fresh water to the Cumberland Sound system. This river is much smaller than the St. Marys and consists of a drainage basin of about 90 square miles with an average freshwater discharge of about 100 cfs. The total fresh water entering Cumberland Sound from the remaining drainage basins is estimated to be less than the Crooked River flow.

11. The relatively low average total freshwater discharge into Cumberland Sound and the relatively high tidal range and associated strong current velocities generally maintain the sound as a well-mixed estuarine system. Salinity within the sound and Kings Bay is generally vertically and laterally homogeneous. Longitudinally, salinity within the sound is only slightly reduced from the ocean entrance conditions. Salinity in Kings Bay typically varies from about 26 to 32 ppt during the year.

PART III: EQUIPMENT DESCRIPTION, PROCEDURES, AND CONDITIONS

Equipment

12. Water level elevations and temperature, conductivity, and salinity measurements were recorded using Environmental Devices Corporation (ENDECO) model 1152 solid state measurement (SSM) water level recorders similar to that shown in Figure 2.

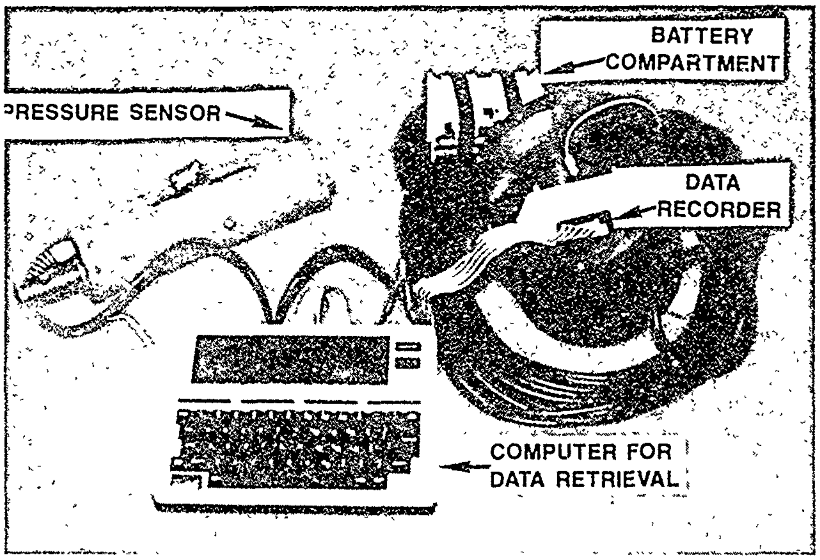

Figure 2. Water level recorder

Water level elevations

13. The ENDECO model 1152 SSM recorders contain a strain gage type pressure transducer located in a subsurface case used to record the absolute pressure of the column of water above the case. The pressure transducer is vented to the atmosphere by a small tube in the signal cable to compensate for any changes in atmospheric pressure. The pressure is measured for 49 sec of each minute of the recording interval with a frequency of 5–55 kHz to filter out surface waves, therefore eliminating the need for a stilling well. The accuracy is ±0.1 percent of full scale. The sampling time interval can be set from 1 min to 1 hr on the 1152 SSM. A 10-min sampling interval was chosen for this study.

Temperature, conductivity,
and salinity measurements

14. Temperature was measured by a thermistor built into the water level recorder. The thermistor has a range of −5° to +45° C, with an accuracy of ±0.2 percent of full scale. Conductivity was measured by an inductively coupled probe. The probe has a range of 0−80 μmho/cm with an accuracy of ±0.55 μmho/cm. Salinity values were then computed from the output of the conductivity and temperature measurements and displayed in units of parts per thousand.

15. The sampling time interval for these parameters was set the same (10 min) as for the water level measurements; they cannot be set independently. The data from each recorder were stored on a removable EPROM solid-state memory cartridge located in a waterproof surface unit, which also contained the d−c power supply.

Measurement Locations

16. A total of six recorders were deployed throughout the Cumberland Sound system as shown in Figure 3. The locations were chosen based on the availability of a mounting structure and relative distances from jetties at the St. Marys entrance. The locations adequately covered the total study area to provide information on differences in time of peak tides and range of tides.

Field Service Procedures

17. WES personnel made periodic trips (usually monthly) to service the equipment. Servicing included first making a visual inspection of the equipment. Then a portable computer was connected to the 1152 SSM to obtain a current display of the data that the sensor was obtaining. These data were compared to in-field checks of salinity and water level. In-field checks of salinity were made using a portable Aanderaa salinity meter, shown in Figure 4. A water sample was also collected at the same depth and returned for laboratory analysis of salinity. The approximate water depth over the sensor was also recorded by measuring the distance from the water surface to a known reference point on the sensor support bracket. The data recording cartridge

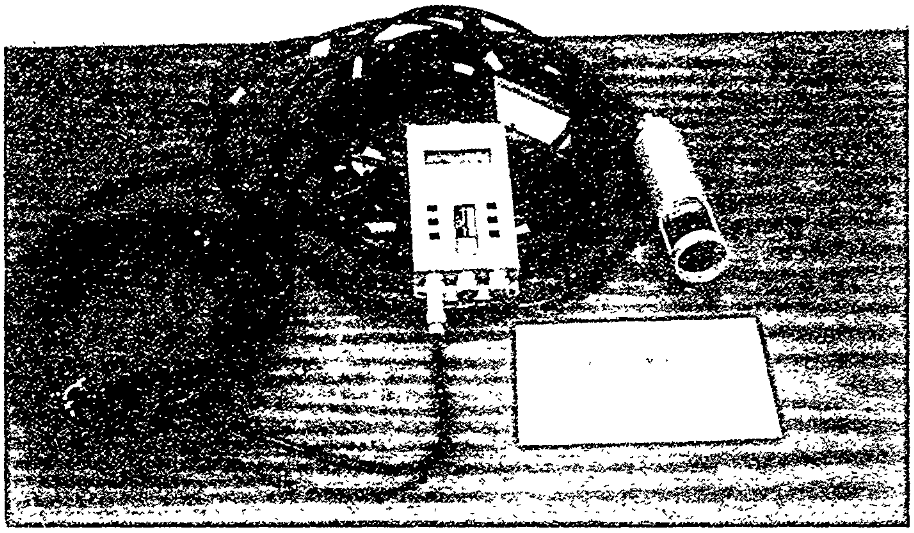

Figure 4. Portable Aanderaa salinity meter

was then removed and replaced with a new cartridge. New batteries were installed and the desiccant, used to displace moisture in the surface housing, was replaced. The subsurface sensor was brought to the surface and inspected and any barnacles or other marine growth removed. After the sensor was cleaned, it was returned to its original position and the computer connected to the 1152 SSM. The instruments' readings were then compared to a new set of in-field measurements. This procedure was performed on all the recording units to verify their proper operation.

Conditions

18. The Cumberland Sound/Kings Bay area enjoys the pleasant temperatures of a semitropical location. Summers are long and warm with mild spring and fall seasons. The winter is short and not too cold. The annual mean temperature is about 70° F with extremes ranging from the teens to 100° F. The yearly average rainfall is 50-55 in. A wide variety of hydrodynamic and weather conditions were sampled during the period of data collection. Most of these conditions could be documented from such data as water level changes and salinity. Freshwater inflows from the St. Marys River are given by stages

recorded from a US Geological Survey (USGS) gaging station located near Gross, FL. These data, gage height, and discharges for the water year January-December 1988 are presented in Tables 1-4 and are excerpted from provisional tables to the unpublished USGS Annual Gage Height and Discharge Report for Water Year 1988.

PART IV: THE DATA

19. The data described herein are available in both tabular and graphical format. Due to the voluminous amounts of data, only representative samples are presented in this report. For more detailed information, the tabulated computer printouts and graphic plots are available upon request.* Tables 5 and 6 are examples of the tabulated format for the water levels (depth of sensor below water surface), salinities, and temperatures available for each data recording location. Time is given in hours and minutes, Eastern Standard Time (EST), for each reading of depth, conductivity, temperature, and salinity. Note that the sampling interval has been set for 10 min.

20. As with any long-term measurement effort, there are periods when the equipment malfunctions for various reasons. The information presented in Table 7 lists the status of each water level-salinity-temperature recorder during the 9-month data collection period (3-15-88 through 12-31-88).

21. Typical examples of the graphical format for the water levels, salinities, and temperatures are presented in Plates 1-30. These plots are presented to illustrate the changes that typically occur during various seasons of the year. Plates 1-9 illustrate the changes in the parameters during the spring sampling period (March-April). Plates 10-18 illustrate the changes that occur during the summer sampling period (July-August). Plates 19-24 show the changes that occur during the fall sampling period (September-November). Plates 25-30 display the changes that occur during the winter sampling period (December). The locations used for the representative samples were chosen to show the changing conditions with the seasons in the St. Marys entrance area (TLR-1, high salinity), in the Navy submarine base (TLR-4, limited freshwater

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* Please send requests for data to the following address:

Commander and Director
US Army Engineer Waterways Experiment Station
ATTN: CEWES-HE-P/Mr. Tim Fagerburg
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Specify the type of data desired and the period of interest. This same information is also available on computer diskettes. Please specify word processor and size of diskettes needed.

inflow), and in the Crooked River area (TLR-5, small watershed, freshwater inflow).

22. Datum planes for the tide data at the locations were arbitrary, since no vertical control had been established in the area at the time of the initial gage installations. The work to establish the tidal benchmarks for each gage installation began in August 1989 and was completed in June 1990. Analyses have been used to determine the mean water level reading for each 30-day period, which has been used as the reference datum plane in each plot.

PART V: SUMMARY

23. The information presented herein represents only a portion of the data collected during the first year of the study. This report is the first in a series of four annual interim data reports. All information from each period of the study will be used to determine if changes to the estuarine processes have occurred due to physical changes made to the navigation channel. This determination will be made through comparisons of the data from this 5-year study to data collected prior to the changed channel conditions.

Table 1

Mean Values of Gage Height for St. Marys River Near Gross, FL

October 1987-September 1988

GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	11.17	11.34	10.92	10.68	10.50	11.82	10.65	11.45	11.08	11.11	11.10	11.82
2	11.08	11.75	10.58	10.80	10.47	11.97	10.68	11.55	10.85	11.52	11.13	11.75
3	10.82	11.96	10.53	11.67	10.41	11.61	10.63	11.12	10.95	11.44	11.30	11.43
4	11.17	11.83	9.74	11.11	10.51	11.23	10.59	10.66	12.02	11.54	11.44	11.09
5	11.25	11.75	10.44	10.65	10.85	10.57	10.50	10.47	11.02	11.70	11.32	10.54
6	11.37	11.86	10.66	10.71	11.00	11.46	10.54	10.60	11.36	12.20	11.00	10.79
7	10.91	11.78	10.95	11.50	11.27	11.38	9.92	11.00	11.04	11.52	10.73	11.92
8	10.79	11.23	11.06	11.03	11.11	11.02	10.95	11.11	10.95	11.39	10.77	12.55
9	11.11	11.06	10.80	10.65	11.14	10.85	11.27	11.29	10.56	10.67	10.96	12.19
10	11.44	10.76	10.52	10.86	11.24	10.13	11.40	11.09	10.33	10.39	10.94	12.01
11	11.50	10.15	10.22	11.26	11.36	11.11	11.64	10.91	11.28	10.47	10.79	12.21
12	11.46	10.91	9.91	11.05	10.24	11.27	11.23	11.06	11.25	10.25	11.07	12.50
13	12.14	11.08	10.20	10.61	9.61	10.68	11.16	10.92	11.19	10.18	11.13	12.48
14	12.20	11.34	10.61	10.93	10.56	10.65	11.61	10.85	10.94	10.23	11.29	12.26
15	12.23	11.43	10.37	11.41	10.85	10.68	11.58	10.96	10.82	10.22	10.79	12.31
16	12.17	11.51	9.65	11.40	10.14	11.01	11.55	10.83	10.87	10.25	10.57	12.67
17	12.16	11.38	10.13	11.14	10.57	11.21	11.50	10.77	10.87	10.31	10.67	12.47
18	11.81	11.17	10.70	10.81	10.91	11.41	11.16	10.83	10.65	10.35	10.67	11.86
19	11.73	11.23	10.86	11.01	11.99	10.97	10.39	10.77	10.69	10.36	10.51	11.93
20	11.76	11.31	10.64	10.97	12.29	10.49	10.89	10.56	10.84	10.39	10.53	11.91
21	11.51	11.00	10.50	11.02	12.09	10.09	10.77	10.59	10.94	10.28	10.58	11.70
22	11.77	11.32	10.80	10.80	11.82	10.51	10.33	10.58	10.98	10.13	10.94	11.86
23	11.82	11.44	11.05	10.75	11.52	10.99	10.49	10.38	10.82	10.15	11.56	12.18
24	11.83	11.25	11.15	10.75	11.09	10.43	10.19	10.14	10.76	10.09	11.38	11.97
25	11.70	11.16	10.85	11.00	11.20	10.23	10.50	10.00	11.08	10.40	11.25	11.69
26	11.90	11.15	10.43	9.87	11.37	10.11	11.48	11.28	11.33	10.69	11.12	11.99
27	11.81	11.17	10.34	10.00	11.15	10.01	11.28	11.71	11.12	10.78	11.26	12.48
28	11.37	11.64	10.78	10.38	11.67	10.38	10.59	11.22	11.77	10.87	11.59	12.26
29	11.32	11.60	10.07	10.30	11.96	10.66	10.56	10.71	11.34	11.01	11.10	12.41
30	11.12	11.28	11.00	10.30	--	10.57	10.61	10.93	10.89	11.17	11.24	12.25
31	11.09	---	10.91	10.41	--	10.55	---	11.07		11.21	11.57	---
MEAN	11.53	11.33	10.57	10.84	11.07	10.84	10.89	10.88	11.05	10.75	11.05	11.98
MAX	12.23	11.96	11.15	11.67	12.29	11.97	11.64	11.71	12.02	12.20	11.59	12.67
MIN	10.79	10.15	9.65	9.87	9.61	10.01	9.92	10.00	10.33	10.09	10.51	10.54

WTR YR 1988 MEAN 11.06 MAX 12.67 MIN 9.61

Note: From provisional tables to the USGS Annual Gage Height and Discharge Report for Water Year 1988.

Table 2

Mean Values of Gage Height for St. Marys River Near Gross, FL

October 1988-September 1989

GAGE HEIGHT, FEET, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	12.03	11.92	10.79	10.80		10.75	10.37	11.02	10.91	12.03	10.56	11.51
2	11.66	11.29	10.54	10.92	--	11.50	10.79	10.64	10.62	11.79	10.78	11.34
3	11.65	11.26	10.43	10.79		11.60	10.86	10.87	10.56	11.43	11.30	11.24
4	11.61	11.52	10.31	10.63		11.21	10.77	11.31	10.63	11.16	11.48	11.77
5	12.02	11.15	11.41	11.07		11.10	10.72	11.37	10.54	11.20	11.06	11.57
6	12.24	10.48	11.17	10.97		11.03	10.46	11.06	10.46	10.79	10.72	11.60
7	12.57	10.24	10.84	10.65		11.00	10.26	10.97	10.59	10.33	10.86	11.95
8	12.66	10.45	10.84	10.89	-	12.02	10.30	11.17	10.49	10.10	11.09	12.29
9	12.45	10.64	10.82	11.03		12.28	10.48	10.95	10.14	10.29	11.73	12.07
10	12.33	10.92	11.28	11.72		12.67	11.04	10.31	9.92	10.58	11.77	11.95
11	11.94	10.85	11.50	11.79		12.41	11.42	10.53	10.30	10.49	11.44	11.80
12	11.47	11.63	12.23	11.57		11.69	11.66	10.83	10.66	10.46	11.31	11.80
13	11.82	11.48	11.74	10.72	-	11.38	11.47	10.74	10.47	10.27	11.36	12.02
14	11.82	11.10	11.13	11.35	--	11.10	11.15	10.83	10.13	10.03	11.33	12.04
15	11.62	11.10	10.80	10.70	10.19	10.60	10.98	10.94	10.12	10.47	11.39	11.76
16	11.49	11.34	11.04	10.34	10.24	10.39	10.94	10.77	10.23	10.64	11.25	11.65
17	11.38	11.06	11.13	10.82	11.19	10.87		10.81	10.28	10.44	11.25	11.49
18	11.39	11.32	11.04	10.82	11.87	10.83	-	10.86	10.37	10.56	11.43	11.80
19	11.29	11.80	10.83	10.47	11.74	10.82	---	11.00	10.62	10.90	11.46	12.13
20	12.08	11.46	10.80	10.41	11.65	11.48	10.78	11.08	10.83	11.02	11.61	11.85
21	12.24	10.85	10.79	11.29	11.32	10.92	11.65	10.94	10.77	11.30	11.62	11.95
22	11.84	11.48	10.83	12.21	10.90	10.94	11.63	10.82	10.73	11.30	11.30	11.20
23	11.87	11.95	11.21	12.22	9.94	12.19	10.92	10.52	10.78	11.33	10.91	11.01
24	11.87	11.79	11.05	--	9.67	11.65	10.73	10.38	10.89	11.26	10.66	11.79
25	11.74	11.60	10.75	---	10.54	11.06	10.60	10.57	10.87	11.13	10.95	12.60
26	11.71	11.40	11.02	-	10.45	10.95	10.31	10.68	11.26	11.37	11.41	11.95
27	11.75	10.97	11.35	--	10.16	10.81	10.53	10.62	11.14	11.16	11.67	12.03
28	11.69	10.15	10.66	--	10.07	10.56	10.87	11.25	11.02	10.56	11.54	13.15
29	11.40	10.66	10.40			10.50	11.13	12.09	10.99	10.55	11.49	12.83
30	11.88	10.96	10.83	--		10.38	11.05	11.62	11.48	10.74	11.48	12.25
31	12.23		10.88	---		10.16		11.20		10.80	11.38	---
MEAN	11.86	11.16	10.90	--		11.19		10.93	10.63	10.85	11.28	11.88
MAX	12.66	11.95	12.23	-	---	12.67	--	12.09	11.48	12.03	11.77	13.15
MIN	11.29	10.15	10.31	---	-	10.14		10.31	9.92	10.03	10.56	11.01

CAL YR 1988 MEAN 11.11 MAX 12.67 MIN 9.61

Note: From provisional tables to the USGS Annual Gage Height and Discharge Report for Water Year 1988.

Table 3

Mean Values of Discharge, cubic feet per second, for St. Marys River Near Gross, FL

October 1987-September 1988

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1987 TO SEPTEMBER 1988
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	-166	338	1710	3640	---	---	---	---	---	---	1600	4000
2	946	503	1140	2580	---	---	---	---	---	---	2000	3950
3	3030	2200	1000	202	---	---	---	---	---	---	1600	3690
4	2700	2120	1700	735	---	---	---	---	---	---	1200	4190
5	2400	2520	-20	2910	---	---	---	---	---	---	1000	4500
6	1300	1700	1530	2900	---	---	---	---	---	---	1600	3380
7	1000	2920	1450	2450	---	---	---	---	---	---	2400	2540
8	1820	2700	2020	2200	---	---	---	---	---	---	2000	6630
9	1750	2200	2270	3150	---	---	---	---	---	---	1600	9250
10	2090	2600	2110	2910	---	---	---	---	---	---	1300	10100
11	2150	2190	2010	2800	---	---	---	---	---	---	1700	10800
12	2140	1290	2160	2510	---	---	---	---	---	---	2200	12000
13	1100	1390	1400	3790	---	---	---	---	---	---	2800	11900
14	2100	1370	1630	1120	---	---	---	---	---	---	3500	12000
15	1450	1490	2030	1010	---	---	---	---	---	---	3400	11600
16	1610	950	1570	1040	---	---	---	---	---	---	3000	11200
17	2040	1900	269	1130	---	---	---	---	---	---	1700	12800
18	2240	1420	210	1070	---	---	---	---	---	---	2500	14200
19	1560	943	800	1010	---	---	---	---	---	---	2200	11300
20	1790	2510	4360	1950	---	---	---	---	---	---	2790	8700
21	2400	1010	4240	2470	---	---	---	---	---	---	2360	6650
22	1410	2020	1440	3670	---	---	---	---	---	---	1390	3750
23	2400	2350	2000	2180	---	---	---	---	---	---	1090	3910
24	2110	2440	1020	333	---	---	---	---	---	---	2100	4170
25	2390	2420	5000	4370	---	---	---	---	---	---	1960	3920
26	1860	1840	1190	499	---	---	---	---	---	---	2610	3210
27	2030	1620	3020	3900	---	---	---	---	---	---	2770	3720
28	2310	822	3400	5350	---	---	---	---	---	---	2850	3970
29	1530	1880	-727	5910	---	---	---	---	---	---	2840	4010
30	1400	1810	6410	2910	---	---	---	---	---	---	3460	4750
31	681	---	2200	5050	---	---	---	---	---	---	3240	---
TOTAL	56451	54274	61590	77959	---	---	---	---	---	---	68840	210790
MEAN	1821	1809	1987	2515	---	---	---	---	---	---	2221	7026
MAX	3030	2920	6410	5910	---	---	---	---	---	---	3500	14200
MIN	-166	338	-727	202	---	---	---	---	---	---	1000	2540
AC-FT	112000	107700	122200	154600	---	---	---	---	---	---	136500	418100

CAL YR 1987 TOTAL 1144310 MEAN 3135 MAX 12000 MIN 727 AC-FT 2270000

Note: From provisional tables to the USGS Annual Gage Height and Discharge Report for Water Year 1988.

Table 4

<u>Mean Values of Discharge, cubic feet per second, for St. Marys River Near Gross, FL</u>

<u>October 1988-September 1989</u>

DISCHARGE, CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	4090	3240	2670	2030		2070	1430	1310	2240	2750	1890	2000
2	3080	3260	1970	1740		2200	1190	1470	2780	3500	1230	2500
3	4330	1490	2040	[illegible]		[illegible]	[illegible]	881	[illegible]	3840	1340	3300
4	5340	1810	1250	1510		[illegible]	[illegible]	2150	3170	3900	1530	4300
5	3030	[illegible]	1260	1350		[illegible]	[illegible]	3030	[illegible]	3330	1500	5300
6	3050	2500	2540	2340		[illegible]	1660	3120	[illegible]	2300	885	5000
7	3510	1620	3000	1240		1560	1640	2290	3320	2420	1180	4200
8	3090	1730	1630	1870		2000	1320	2560	3550	2710	1230	3700
9	3940	2050	1030	2310		[illegible]	1540	3130	3300	2030	1050	3300
10	3030	2370	1740	[illegible]		[illegible]	1760	[illegible]	[illegible]	[illegible]	2090	2300
11	3760	2500	2810	3100		2300	2230	1250	2360	2170	1720	2300
12	3410	2320	2000	3430		2300	1290	2070	2440	1750	1200	1900
13	2850	3510	4640	3350		2250	2150	2020	3170	1820	1290	1500
14	3630	3050	3440	2510		2220	1850	1540	[illegible]	1760	425	1700
15	3370	2450	3370	3100	1720	2110	1740	1950	2610	1160	1280	2000
16	3200	2100	2320	2110	1610	1750	1570	1840	2680	2360	1640	2400
17	2810	2560	2080	1400	1220	1320		1550	2830	2310	2340	2700
18	2270	1130	2000	1760	1960	1600		1020	3450	2320	2540	3000
19	2310	1200	1970	1000	2240	1210		2410	3710	2560	2170	3500
20	138	3160	1600	1750	2120	1610	1620	3600	1150	2510	2630	3800
21	3260	1790	1600	338	2190	2060	2430	2970	4650	2500	2770	2700
22	2570	1680	1370	2020	2300	1520	3080	2630	4650	2770	2260	2000
23	2320	3580	2080	2700	2710	2130	3350	3140	4520	2910	1390	1700
24	3160	2970	2770		1740	2000	2320	2570	4440	2600	793	2000
25	2790	3570	2610		2160	2510	2600	2700	4030	1840	3300	2400
26	3160	3250	2170		2450	[illegible]	2450	2770	[illegible]	1520	2100	3000
27	2870	3150	3000		2250	2050	2130	2600	2250	1350	1760	3500
28	3240	3640	3210		2340	2000	2030	772	[illegible]	522	1500	4000
29	2950	2050	2130			2040	1880	1710	2090	241	1250	4600
30	2420	2710	2460		-	1800	1570	2570	1430	55	1400	5200
31	2760	-	2180			1970		2320		1420	1650	-
TOTAL	97982	75970	73900	-		61850		70793	94120	67578	51533	92300
MEAN	3161	2532	2384	-		1995	-	2284	3137	2178	1662	3077
MAX	5340	3640	4640	-		2800	-	3140	4650	3900	3300	5300
MIN	·138	1130	1250			1190		881	1430	55	425	1500
AC-FT	194300	150700	146600			122700		140400	186700	133900	102200	183100

Note: From provisional tables to the USGS Annual Gage Height and Discharge Report for Water Year 1988.

Table 5

Sample Printout of Water Level Recorder Data for Station TLR-1

Kings Bay - Station TLR-1 - 20 March 1988

ENDECO TYPE 1152 DENSITY COMPENSATING WATER LEVEL RECORDER
DATUM OFFSET APPLIED: .000 (FEET)
SERIAL NUMBER: 11520147

DATE (MM/DD/YY)	TIME (HH:MM)	TEMPERATURE (CELSIUS)	CONDUCTIVITY (MMHO/CM)	SALINITY (PPT)	DEPTH (FEET)
03/20/88	05:10	12.57	36.59	31.2	2.465
03/20/88	05:20	12.66	35.97	30.6	2.711
03/20/88	05:30	12.74	36.50	31.0	2.944
03/20/88	05:40	12.76	36.44	30.9	3.227
03/20/88	05:50	12.75	36.70	31.2	3.476
03/20/88	06:00	12.74	37.16	31.6	3.699
03/20/88	06:10	12.72	37.74	32.2	3.975
03/20/88	06:20	12.65	38.73	33.2	4.209
03/20/88	06:30	12.62	38.70	33.2	4.510
03/20/88	06:40	12.64	38.75	33.2	4.620
03/20/88	06:50	12.68	38.79	33.2	5.029
03/20/88	07:00	12.72	38.84	33.2	5.244
03/20/88	07:10	12.69	38.79	33.2	5.543
03/20/88	07:20	12.64	38.74	33.2	5.804
03/20/88	07:30	12.64	38.76	33.2	6.056
03/20/88	07:40	12.66	38.76	33.2	6.287
03/20/88	07:50	12.65	38.76	33.2	6.491
03/20/88	08:00	12.66	38.77	33.2	6.735
03/20/88	08:10	12.69	38.82	33.2	6.924
03/20/88	08:20	12.75	38.87	33.2	7.111
03/20/88	08:30	12.77	38.88	33.2	7.282
03/20/88	08:40	12.78	38.89	33.2	7.445
03/20/88	08:50	12.79	38.91	33.2	7.598
03/20/88	09:00	12.80	38.91	33.2	7.752
03/20/88	09:10	12.84	38.94	33.2	7.898
03/20/88	09:20	12.86	38.96	33.2	8.017
03/20/88	09:30	12.87	38.97	33.2	8.086
03/20/88	09:40	12.88	38.98	33.2	8.104
03/20/88	09:50	12.89	39.00	33.2	8.145
03/20/88	10:00	12.90	39.00	33.2	8.072
03/20/88	10:10	12.87	38.66	32.9	8.070
03/20/88	10:20	12.71	38.29	32.7	8.011
03/20/88	10:30	12.77	38.38	32.8	7.904
03/20/88	10:40	12.90	38.65	32.9	7.809
03/20/88	10:50	12.93	38.70	32.9	7.675
03/20/88	11:00	13.01	38.89	33.0	7.511

Table 6

Sample Printout of Water Level Recorder Data for Station TLR-4

Kings Bay - Station TLR-4 - 20 March 1988

ENDECO TYPE 1152 DENSITY COMPENSATING WATER LEVEL RECORDER
DATUM OFFSET APPLIED: .000 (FEET)
SERIAL NUMBER: 11520279

DATE (MM/DD/YY)	TIME (HH:MM)	TEMPERATURE (CELSIUS)	CONDUCTIVITY (MMHO/CM)	SALINITY (PPT)	DEPTH (FEET)
03/20/88	05:10	12.91	29.47	24.4	2.231
03/20/88	05:20	12.92	29.49	24.4	2.465
03/20/88	05:30	12.92	29.48	24.4	2.709
03/20/88	05:40	12.91	29.48	24.4	2.985
03/20/88	05:50	12.91	29.48	24.4	3.277
03/20/88	06:00	12.90	29.48	24.4	3.560
03/20/88	06:10	12.94	29.54	24.4	3.844
03/20/88	06:20	12.95	29.63	24.5	4.142
03/20/88	06:30	12.94	29.61	24.5	4.423
03/20/88	06:40	12.91	29.60	24.5	4.701
03/20/88	06:50	12.93	29.73	24.6	4.971
03/20/88	07:00	13.00	29.37	24.2	5.245
03/20/88	07:10	13.04	29.17	24.0	5.502
03/20/88	07:20	13.02	29.02	23.9	5.765
03/20/88	07:30	13.03	29.03	23.9	6.029
03/20/88	07:40	13.03	29.04	23.9	6.297
03/20/88	07:50	13.05	29.05	23.9	6.539
03/20/88	08:00	13.06	29.23	24.0	6.782
03/20/88	08:10	13.05	29.12	24.0	7.026
03/20/88	08:20	13.06	28.98	23.8	7.244
03/20/88	08:30	13.06	29.00	23.8	7.464
03/20/88	08:40	13.08	29.14	23.9	7.682
03/20/88	08:50	13.12	29.36	24.1	7.891
03/20/88	09:00	13.12	29.35	24.1	8.075
03/20/88	09:10	13.13	29.32	24.1	8.248
03/20/88	09:20	13.14	29.33	24.1	8.411
03/20/88	09:30	13.15	29.44	24.2	8.549
03/20/88	09:40	13.17	29.84	24.5	8.671
03/20/88	09:50	13.19	29.89	24.6	8.795
03/20/88	10:00	13.19	29.79	24.5	8.829
03/20/88	10:10	13.19	29.87	24.5	8.929
03/20/88	10:20	13.20	29.92	24.6	8.962
03/20/88	10:30	13.20	29.93	24.6	8.974
03/20/88	10:40	13.21	29.57	24.3	8.961
03/20/88	10:50	13.24	29.56	24.2	8.941
03/20/88	11:00	13.25	29.68	24.3	8.887

Table 7

Status of Water Level, Salinity and Temperature Recording Gages

Station No.	Data Period Beginning Date	Data Period Ending Date	Comments
TLR-1	3/16/88	4/20/88	
	4/20/88	5/15/88	
	5/16/88	6/04/88	Conductivity probe malfunction
	6/04/88	7/13/88	Gage removed for service
	7/13/88	8/17/88	
	8/17/88	12/30/88	Gage supporting structure destroyed
TLR-2	3/15/88	4/19/88	
	4/19/88	5/14/88	
	5/14/88	6/14/88	
	6/14/88	7/14/88	
	7/14/88	8/16/88	
	8/16/88	9/27/88	
	9/27/88	11/02/88	
	11/02/88	12/06/88	
	12/06/88	12/31/88	
TLR-3	3/15/88	4/19/88	
	4/19/88	5/14/88	
	5/14/88	6/14/88	
	6/14/88	7/14/88	
	7/14/88	8/16/88	
	8/16/88	9/27/88	
	9/27/88	11/02/88	
	11/02/88	12/06/88	
	12/06/88	12/31/88	
TLR-4	3/15/88	4/19/88	
	4/19/88	5/14/88	
	5/14/88	6/14/88	
	6/14/88	7/14/88	
	7/14/88	8/16/88	
	8/16/88	9/27/88	
	9/27/88	11/02/88	
	11/02/88	12/06/88	
	12/06/88	12/31/88	
TLR-5	3/15/88	4/19/88	
	4/19/88	5/14/88	
	5/14/88	6/14/88	
	6/14/88	7/14/88	
	7/14/88	8/16/88	
	8/16/88	9/27/88	
	9/27/88	11/02/88	
	11/02/88	12/06/88	
	12/06/88	12/31/88	

(Continued)

Table 7 (Concluded)

Station No.	Data Period: Beginning Date	Data Period: Ending Date	Comments
TLR-6	3/15/88	4/19/88	
	4/19/88	5/14/88	
	5/14/88	6/14/88	
	6/14/88	7/14/88	Gage malfunction; removed for service
	7/14/88	8/16/88	
	8/16/88	9/18/88	No data collected; bad memory cartridge
	9/18/88	12/31/88	Gage structure destroyed; gage lost

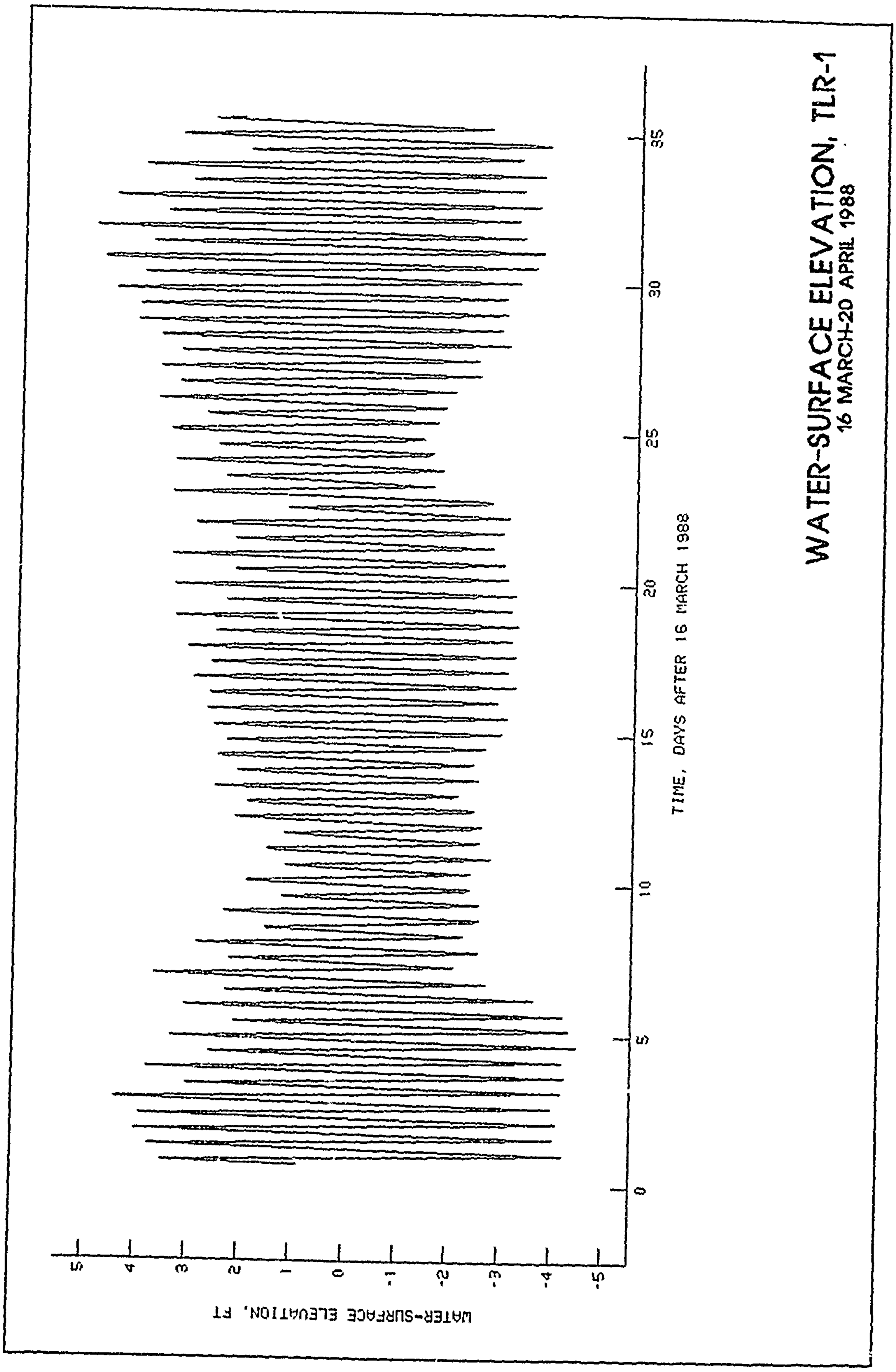

WATER-SURFACE ELEVATION, TLR-1
16 MARCH-20 APRIL 1988
TIME, DAYS AFTER 16 MARCH 1988
WATER-SURFACE ELEVATION, FT
0
5
10
15
20
25
30
35
5
4
3
2
1
0
-1
-2
-3
-4
-5

PLATE 1

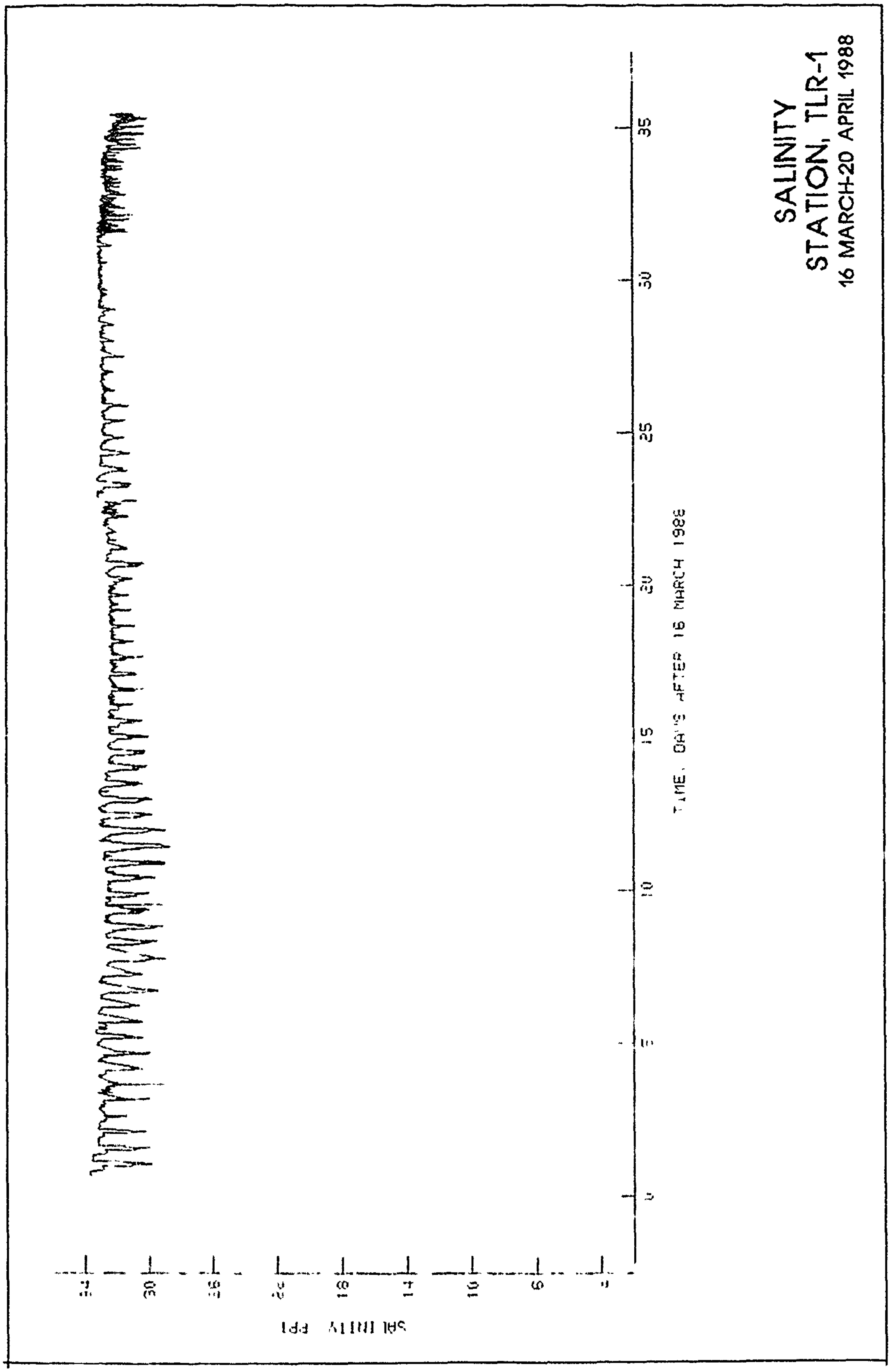
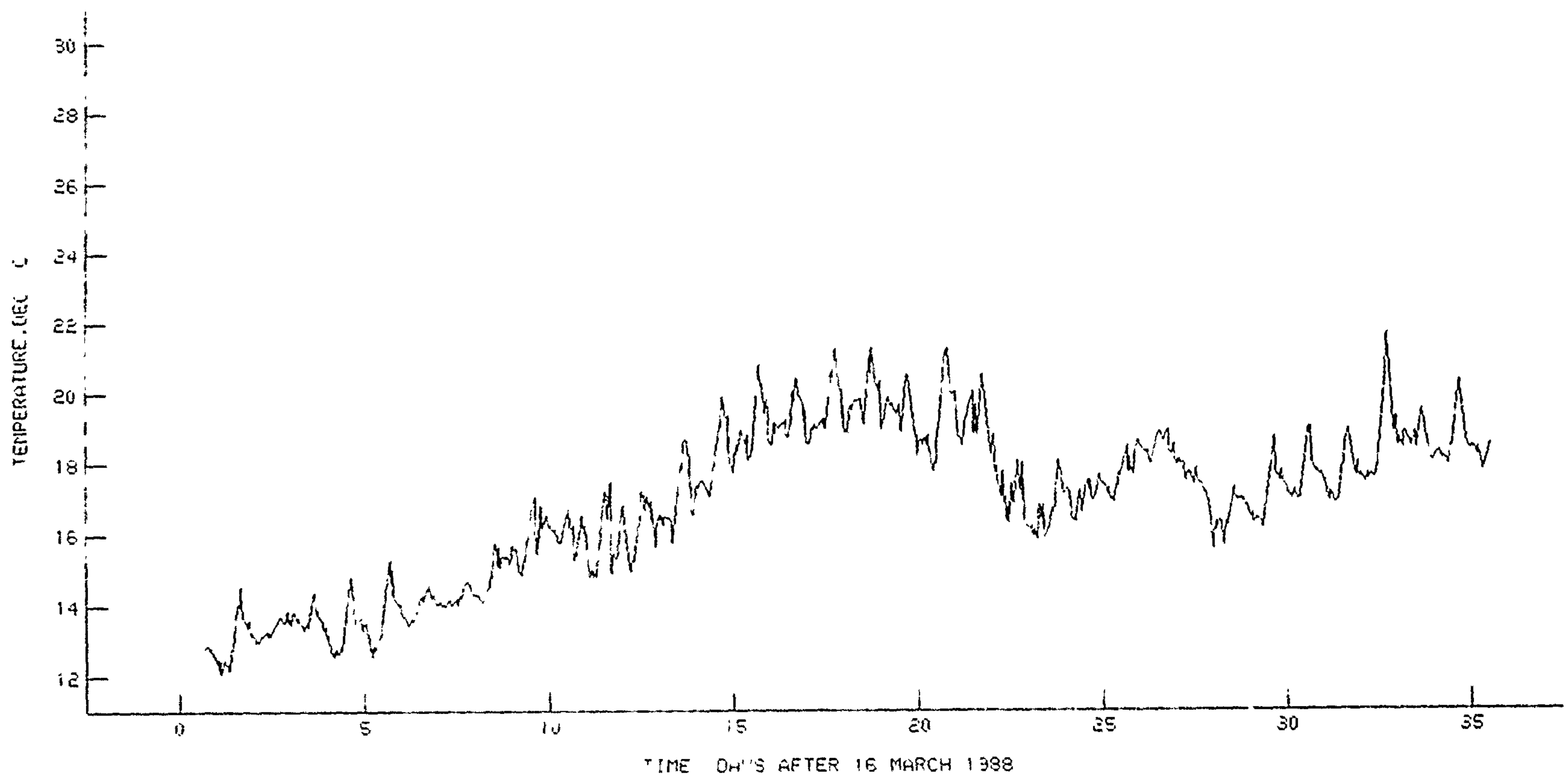
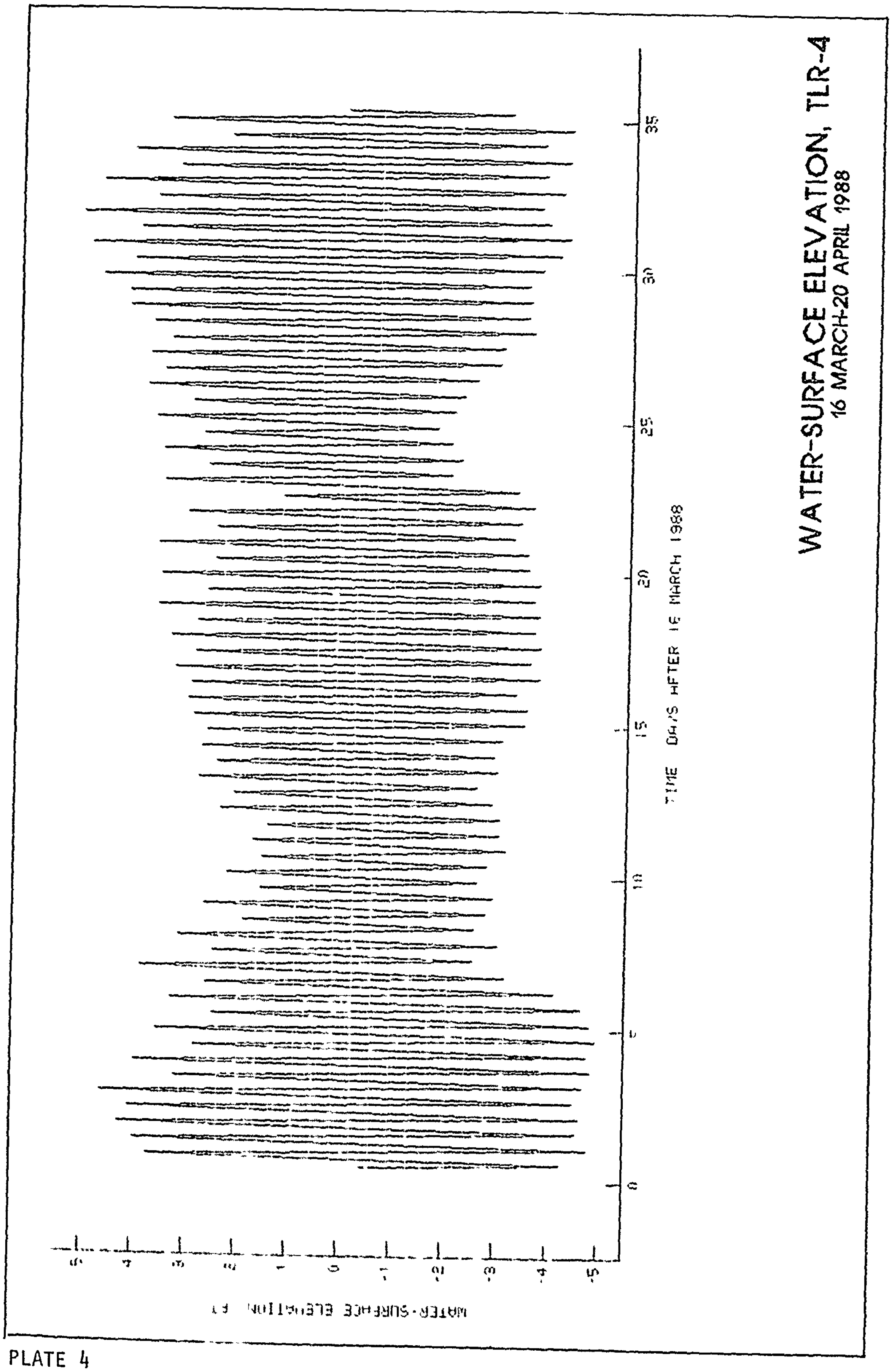

SALINITY
STATION, TLR-1
16 MARCH-20 APRIL 1988
TIME, DAYS AFTER 16 MARCH 1988
SALINITY PPT
0
5
10
15
20
25
30
35

PLATE 2



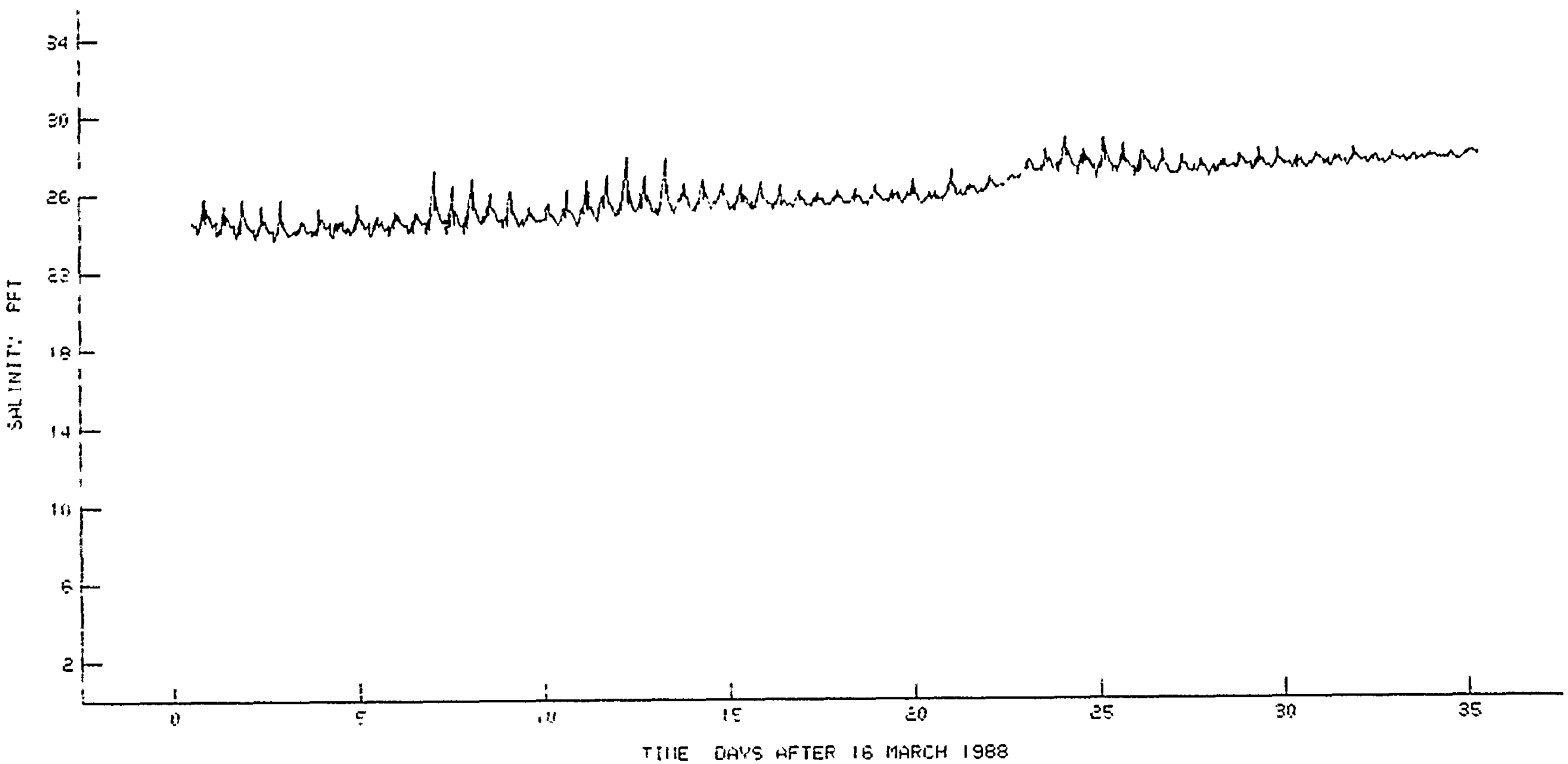
TEMPERATURE
STATION, TLR-1
16 MARCH-20 APRIL 1988

PLATE 3



WATER-SURFACE ELEVATION, TLR-4
16 MARCH-20 APRIL 1988
TIME DAYS AFTER 16 MARCH 1988
WATER-SURFACE ELEVATION, FT

PLATE 4



SALINITY
STATION, TLR-4
16 MARCH-20 APRIL 1988

PLATE 5

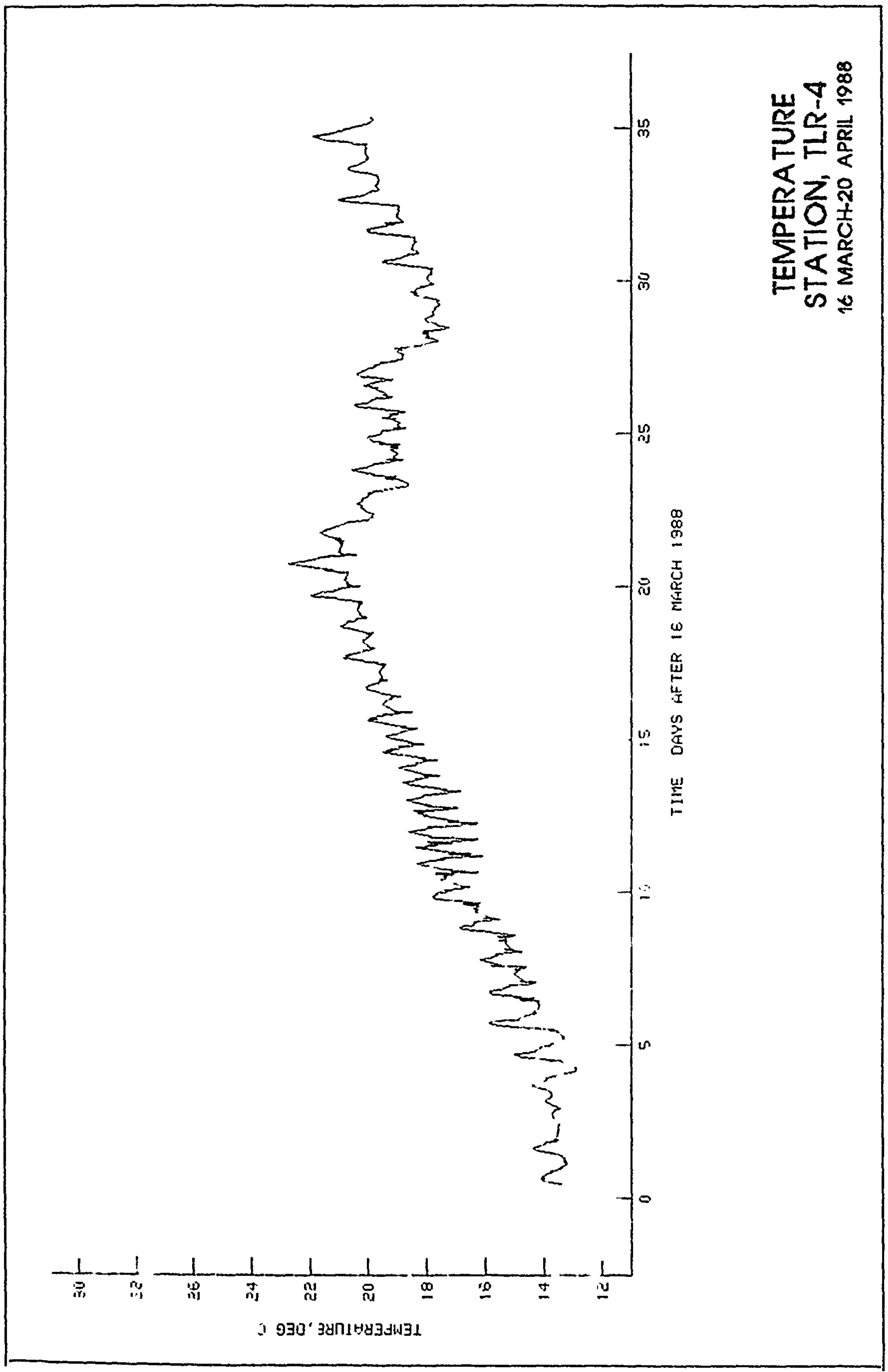

TEMPERATURE
STATION, TLR-4
16 MARCH-20 APRIL 1988
TIME DAYS AFTER 16 MARCH 1988
TEMPERATURE, DEG C
0
5
15
20
25
30
35
12
14
16
18
20
22
24
26
30

PLATE 6

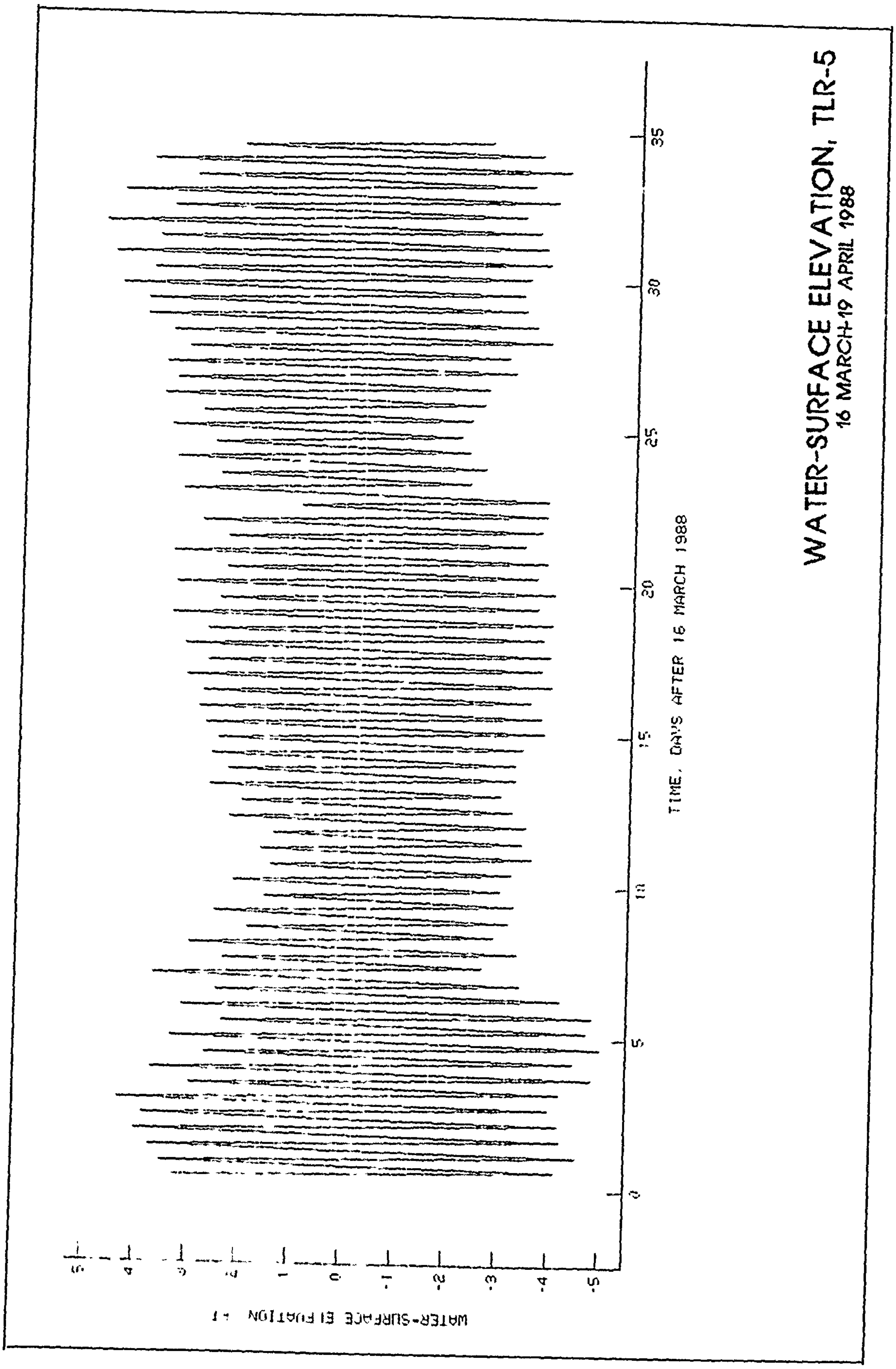

WATER-SURFACE ELEVATION, TLR-5
16 MARCH-19 APRIL 1988
TIME, DAYS AFTER 16 MARCH 1988
WATER-SURFACE ELEVATION, FT
0
5
10
15
20
25
30
35
5
4
3
2
1
0
-1
-2
-3
-4
-5

PLATE 7

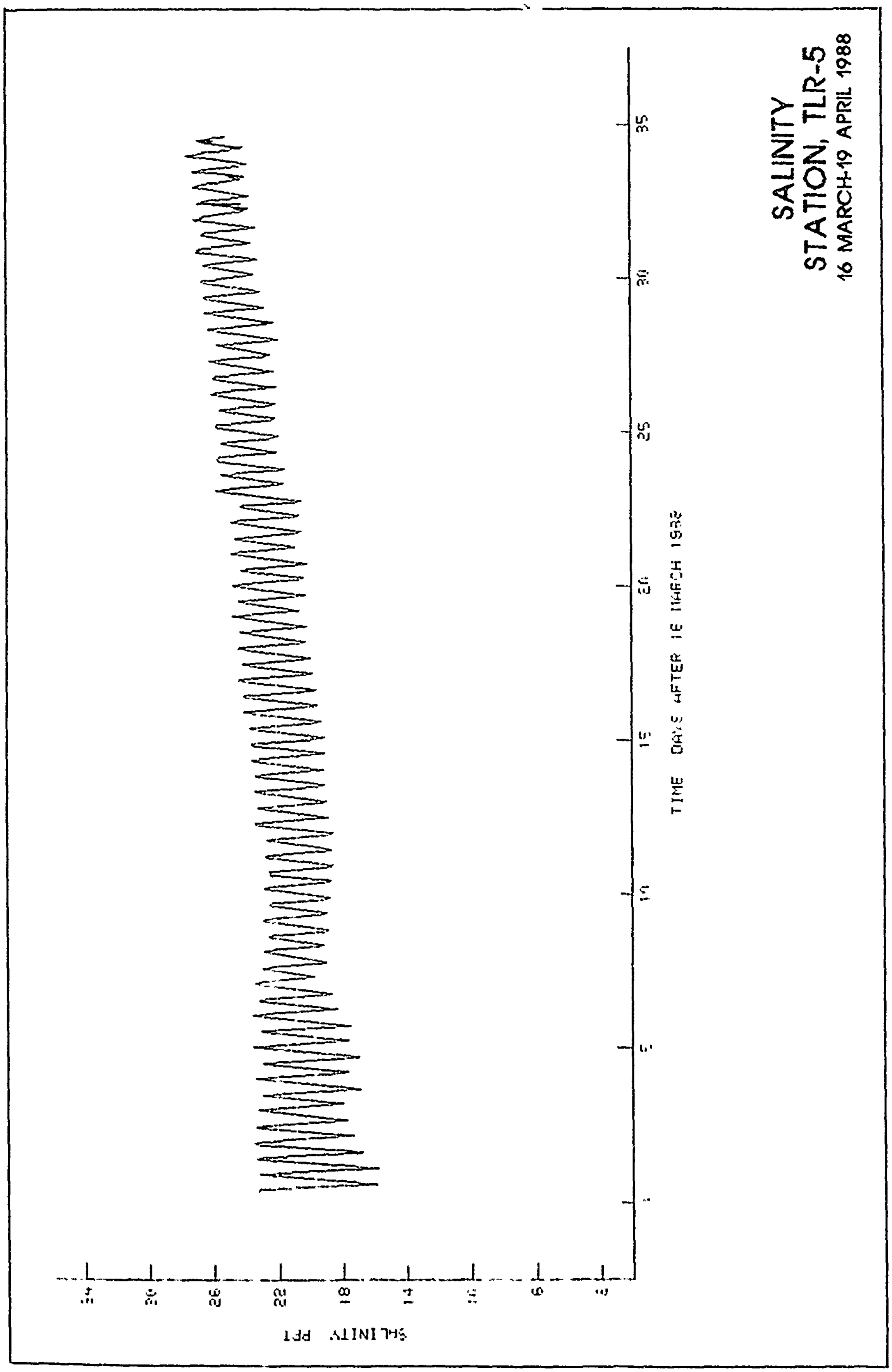

SALINITY
STATION, TLR-5
16 MARCH-19 APRIL 1988
SALINITY PPT
26
22
18
14
6
15
25
35

PLATE 8

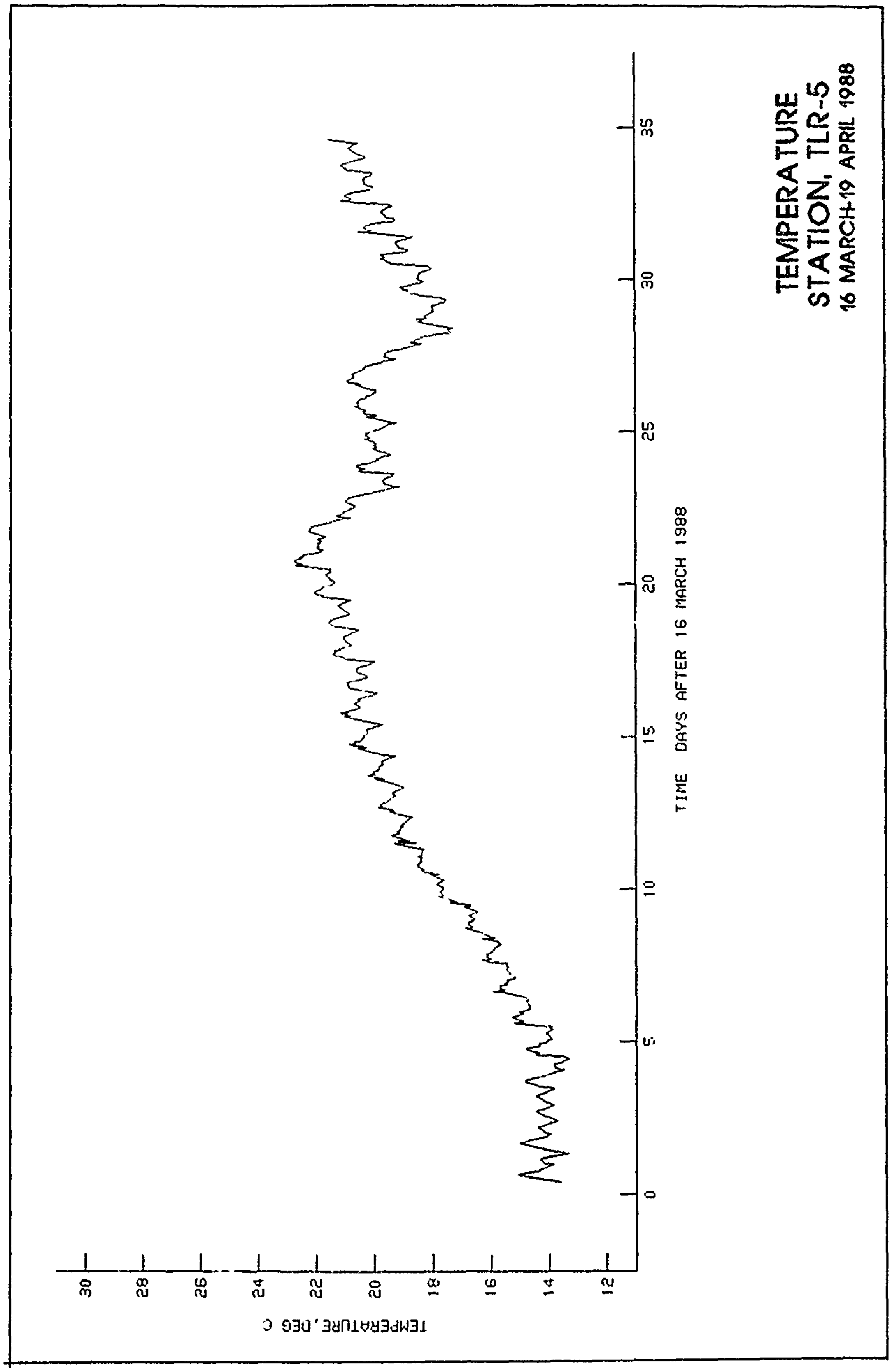

TEMPERATURE
STATION, TLR-5
16 MARCH-19 APRIL 1988
TIME DAYS AFTER 16 MARCH 1988
TEMPERATURE, DEG C

PLATE 9

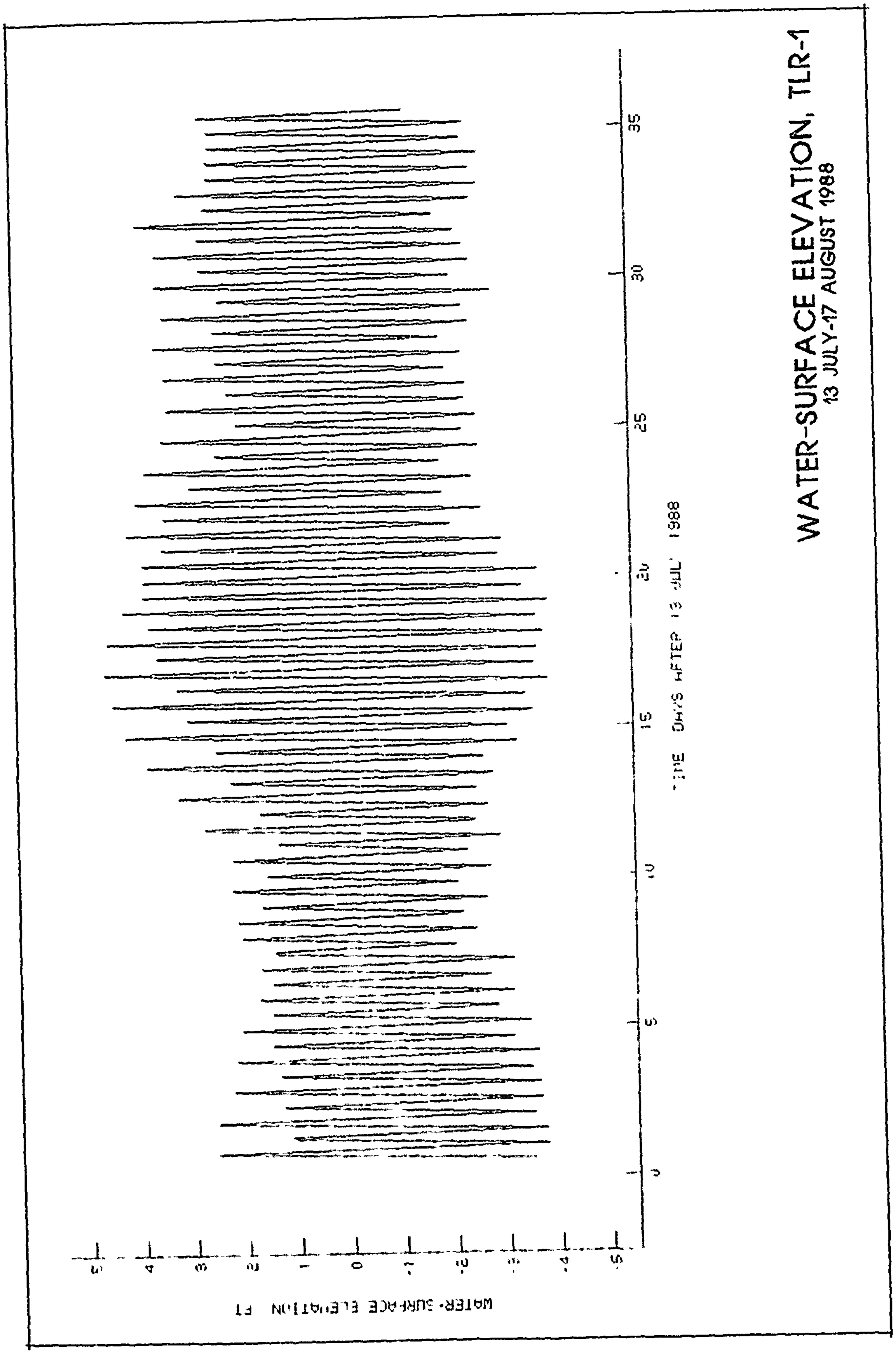
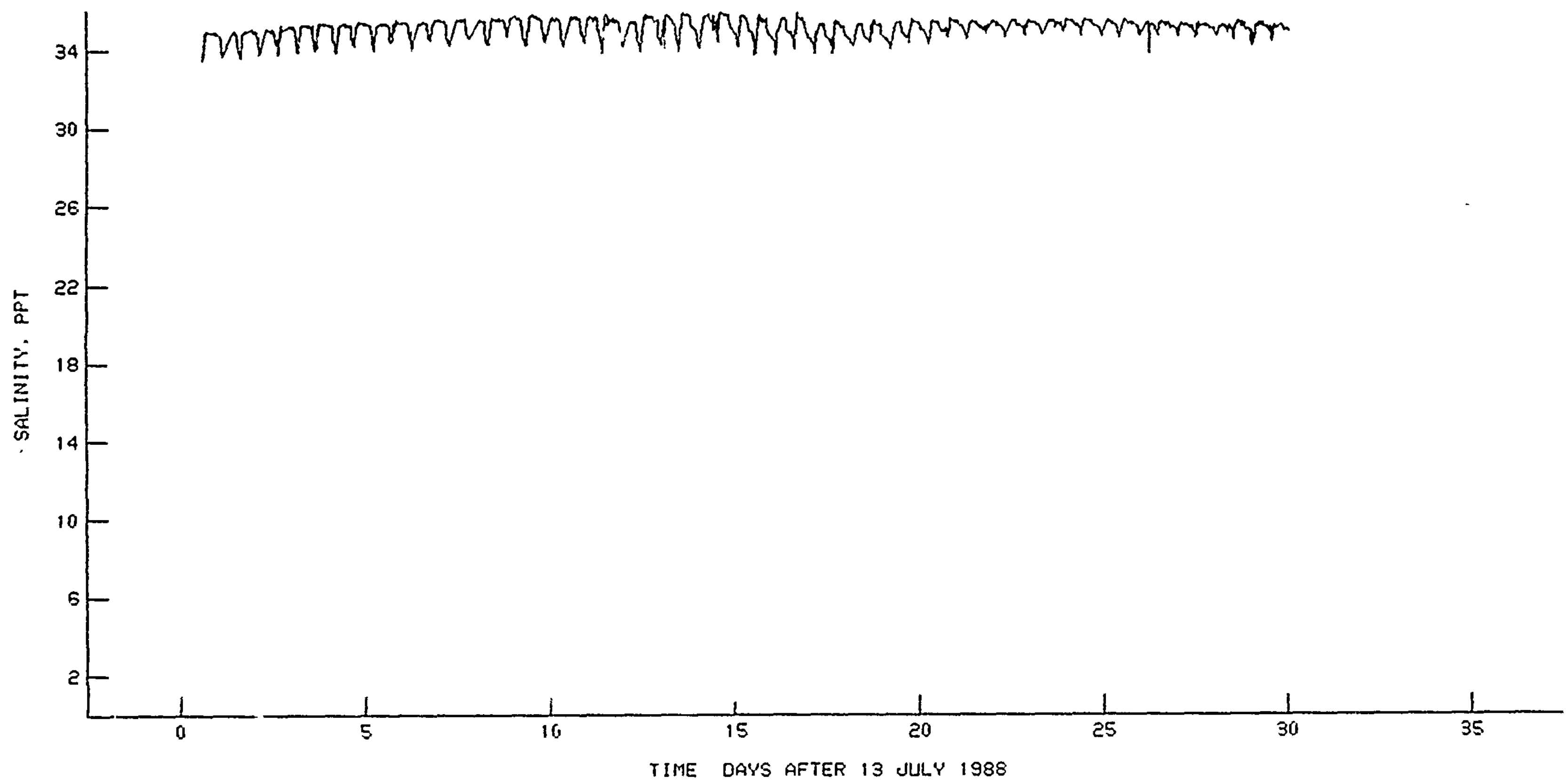

WATER-SURFACE ELEVATION, TLR-1
13 JULY-17 AUGUST 1988
TIME DAYS AFTER 13 JUL 1988
WATER-SURFACE ELEVATION FT

PLATE 10



SALINITY
STATION, TLR-1
13 JULY-17 AUGUST 1988

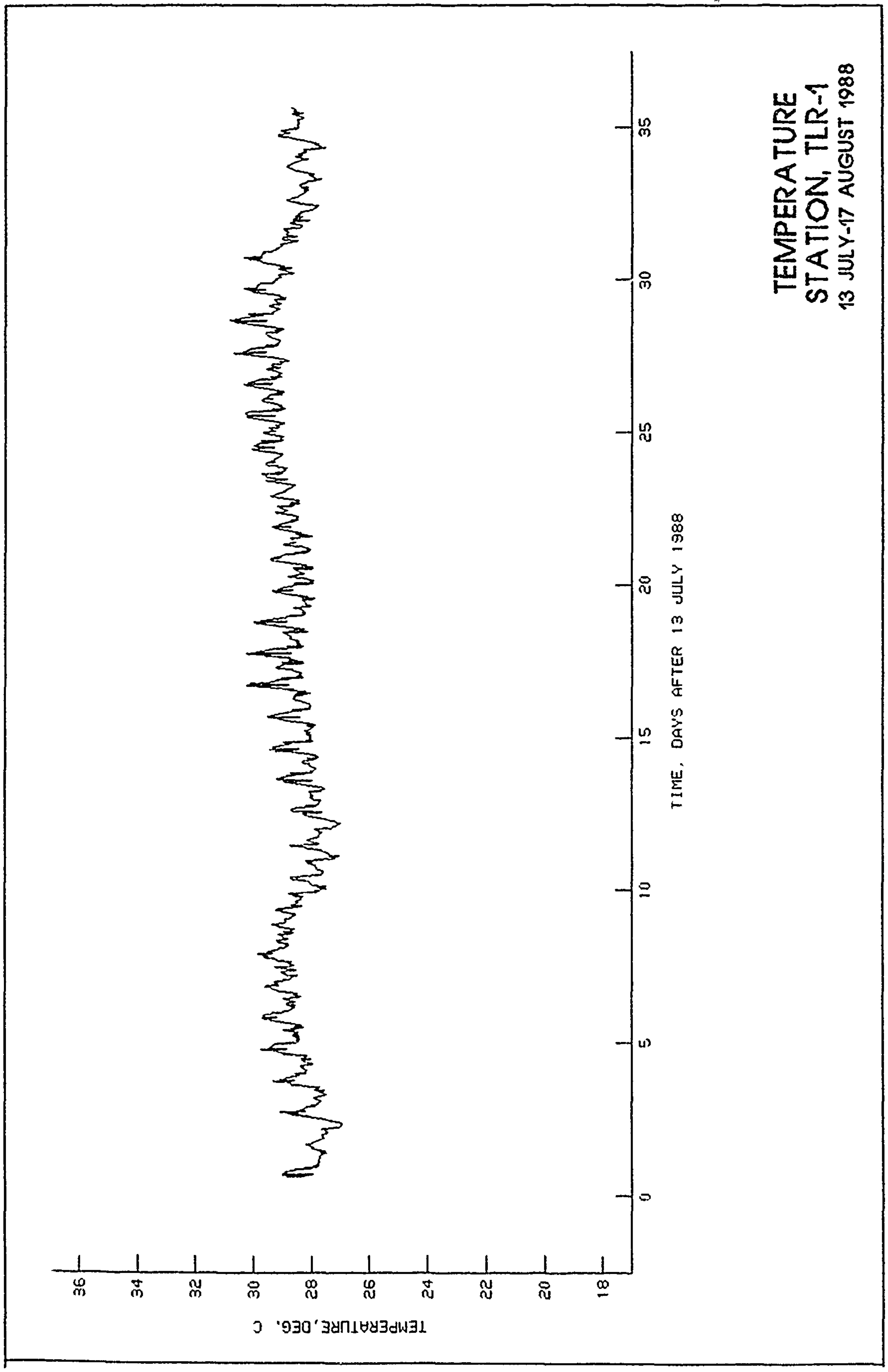
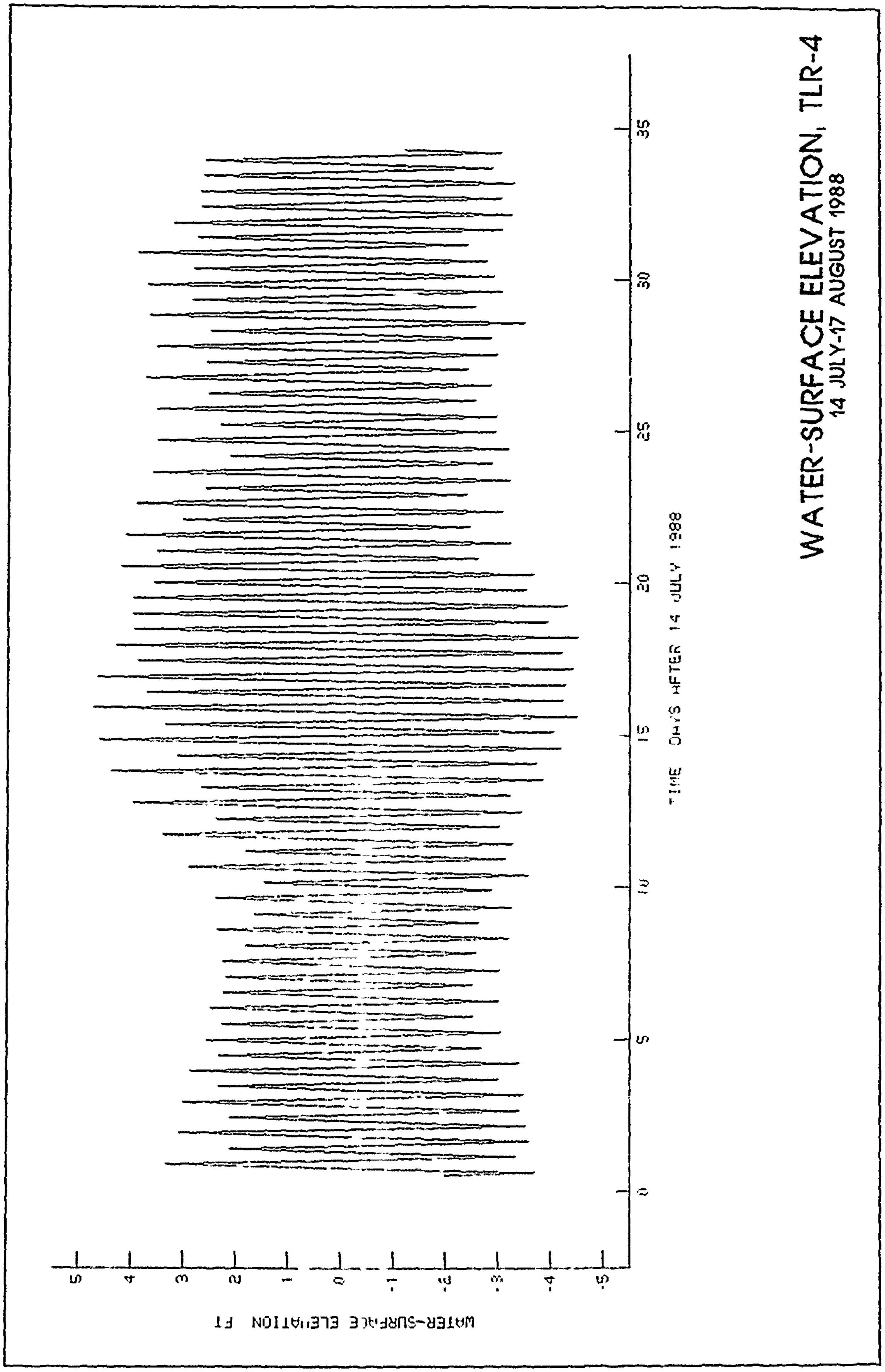

TEMPERATURE
STATION, TLR-1
13 JULY-17 AUGUST 1988
TEMPERATURE, DEG. C
18
20
22
24
26
28
30
32
34
36
TIME, DAYS AFTER 13 JULY 1988
0
5
10
15
20
25
30
35

PLATE 12



WATER-SURFACE ELEVATION, TLR-4
14 JULY-17 AUGUST 1988
TIME DAYS AFTER 14 JULY 1988
WATER-SURFACE ELEVATION FT
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
5
10
15
20
25
30
35

PLATE 13

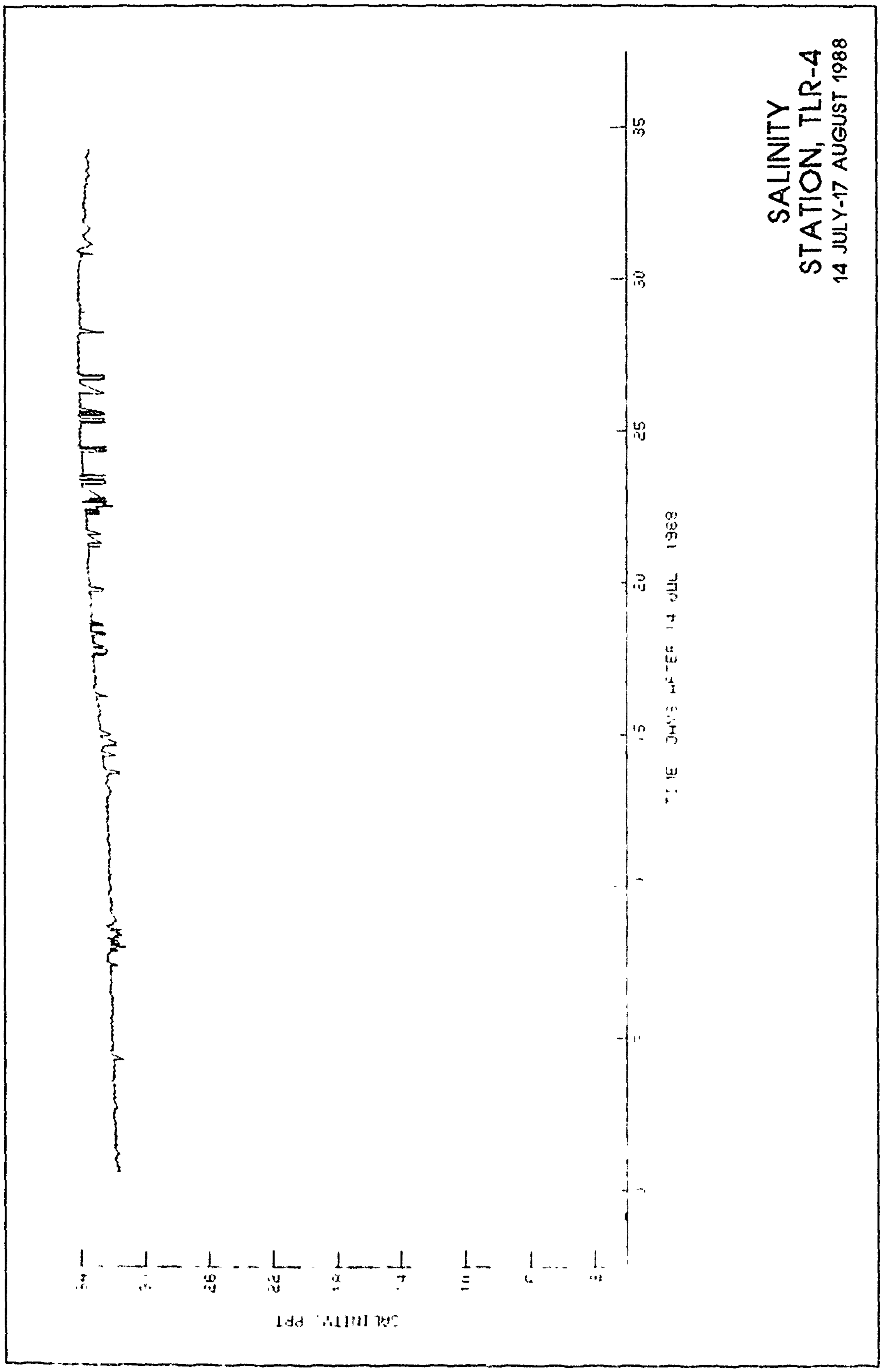
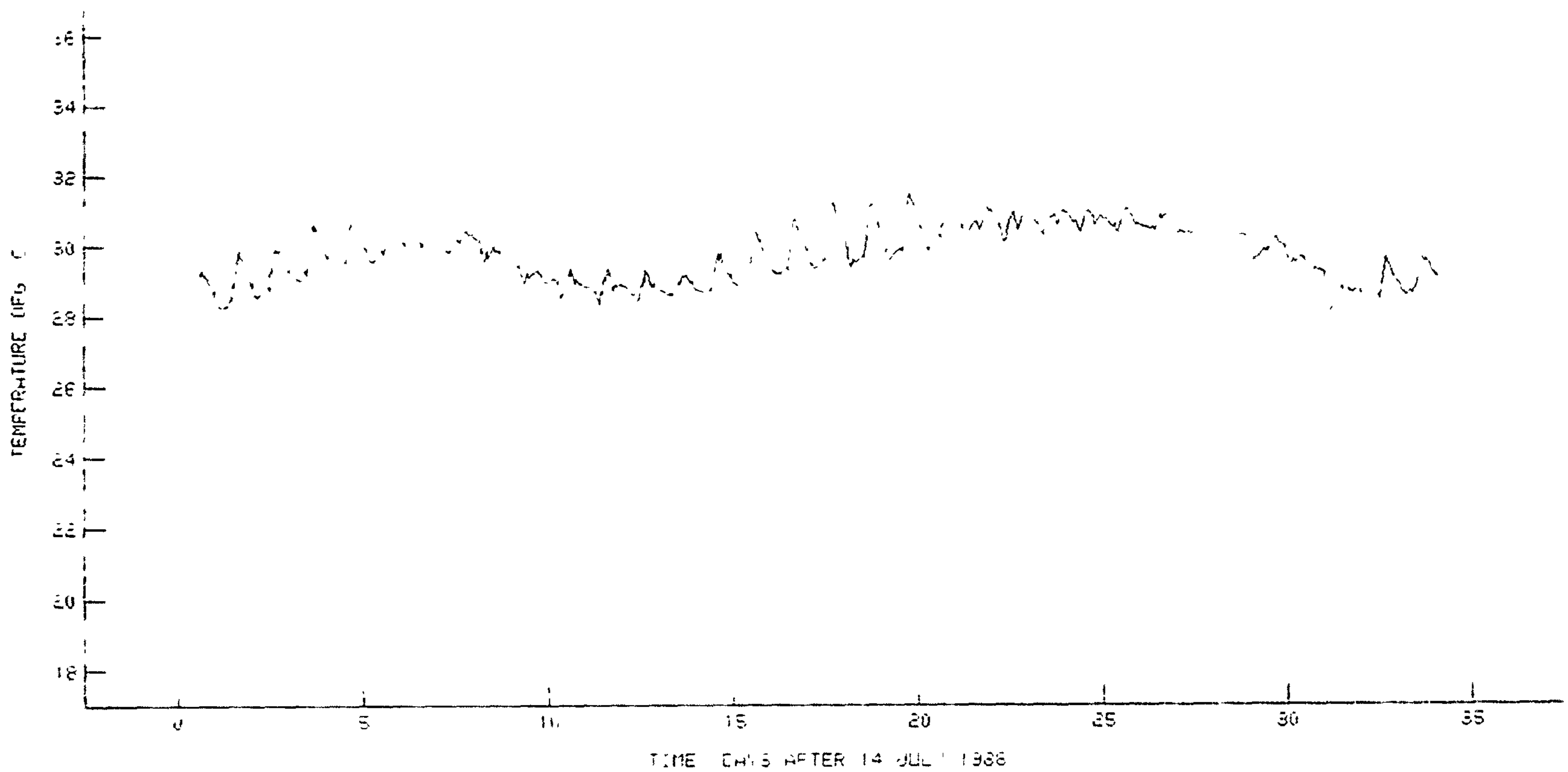


PLATE 14



TEMPERATURE
STATION, TLR-4
14 JULY-17 AUGUST 1988

PLATE 15

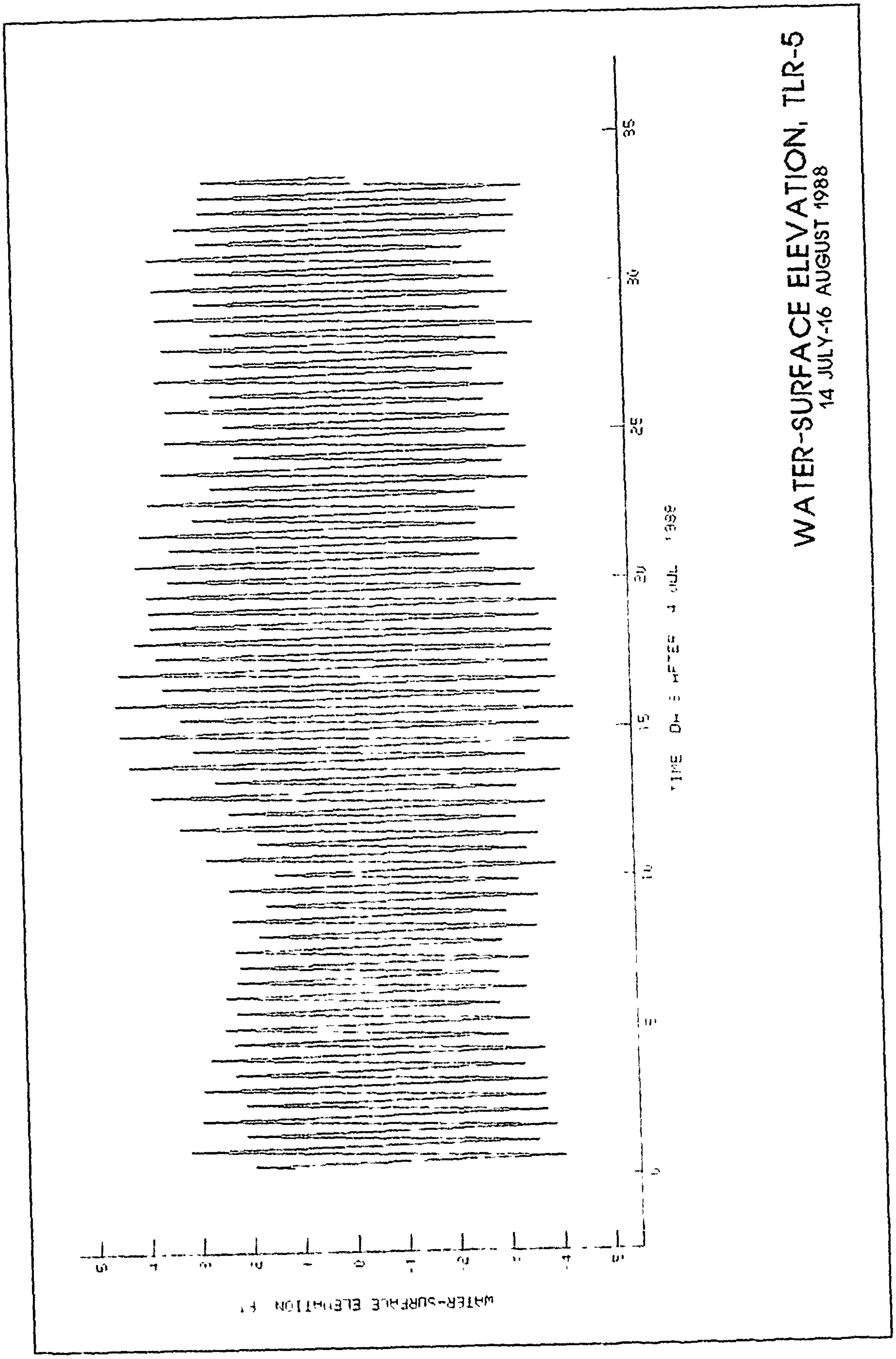


PLATE 16

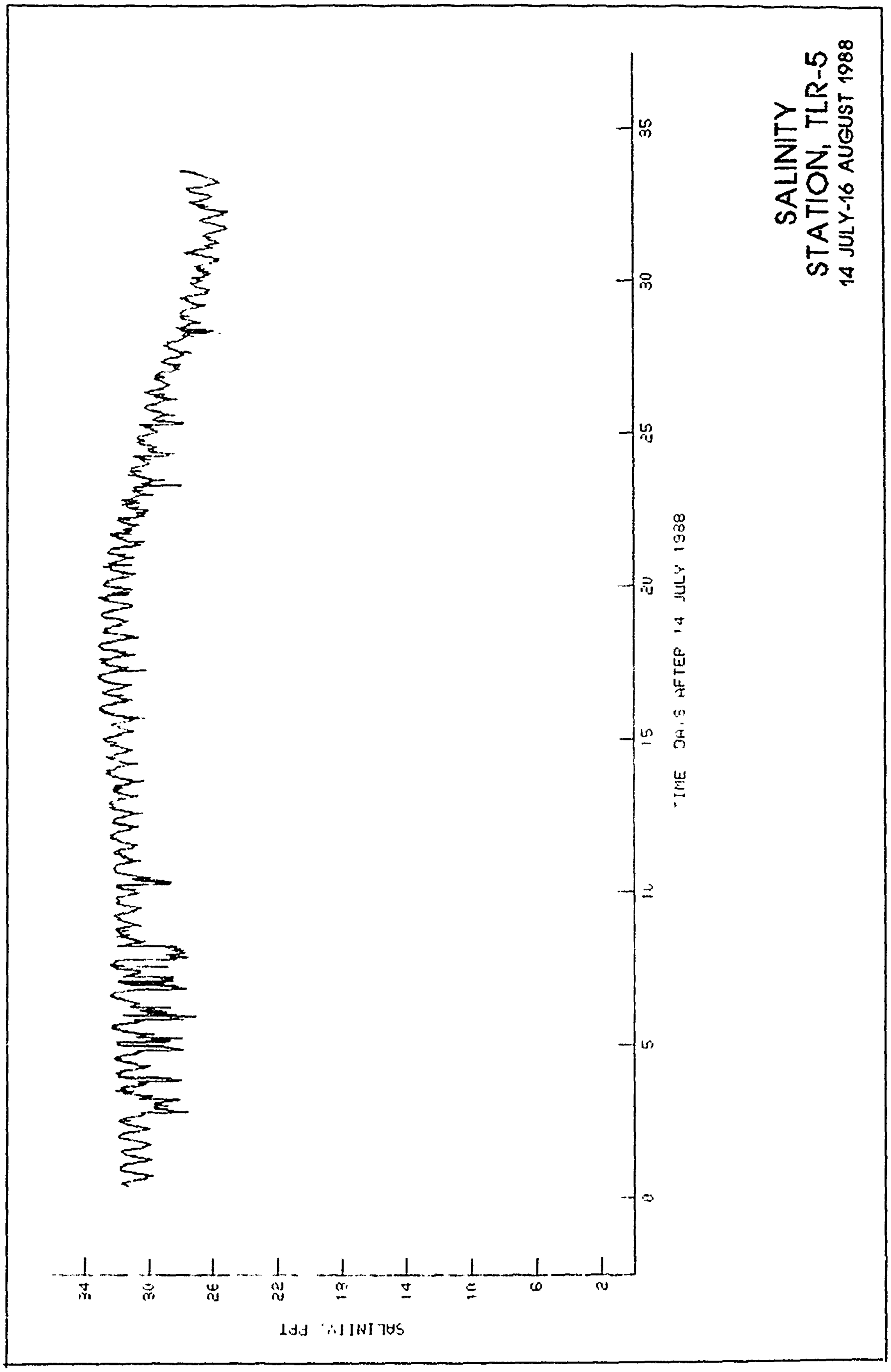
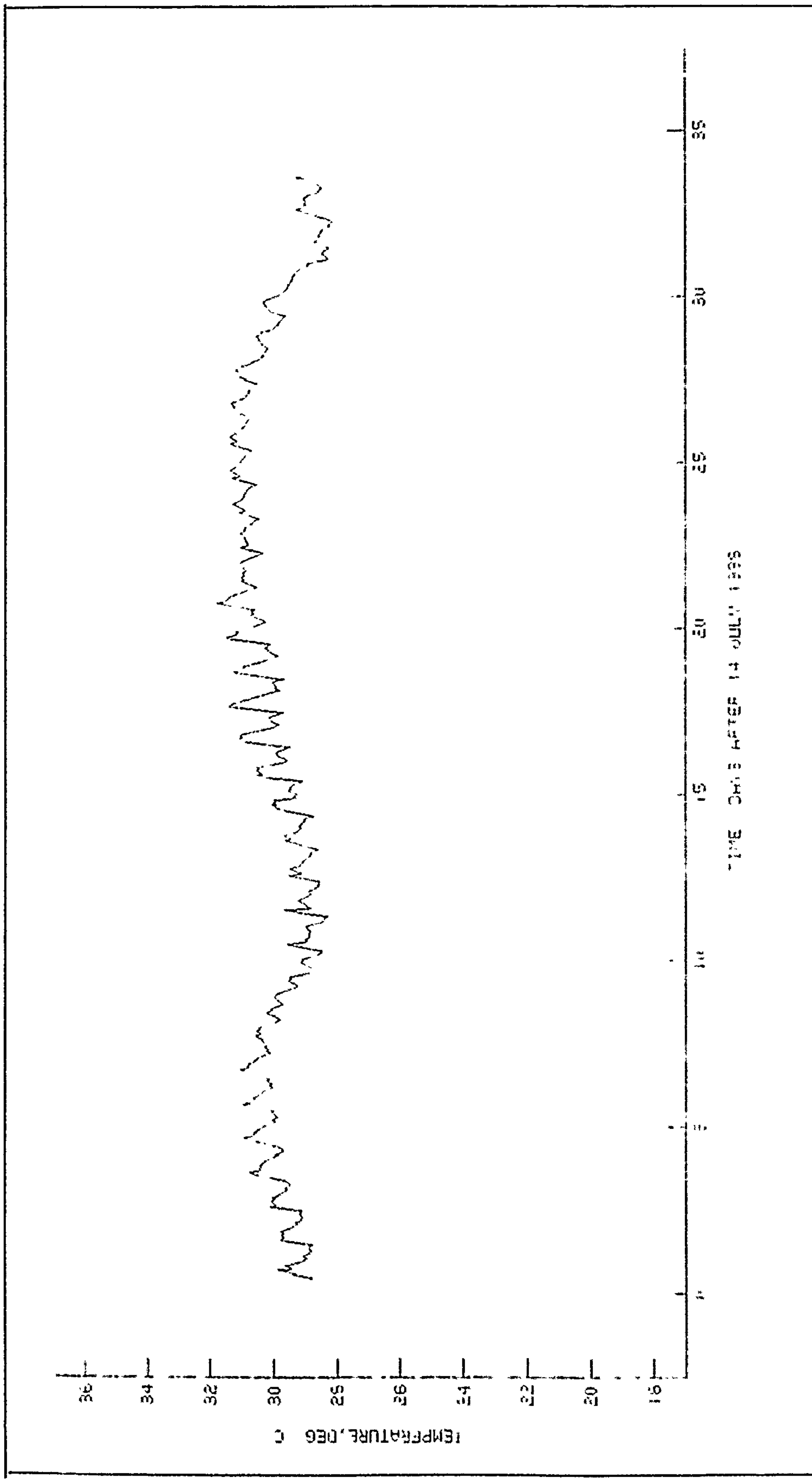

SALINITY
STATION, TLR-5
14 JULY-16 AUGUST 1988
TIME DAYS AFTER 14 JULY 1988
SALINITY, PPT
34
30
26
22
18
14
10
6
2
0
5
10
15
20
25
30
35

PLATE 17



TEMPERATURE
STATION, TLR-5
14 JULY - 16 AUGUST 1988

PLATE 18

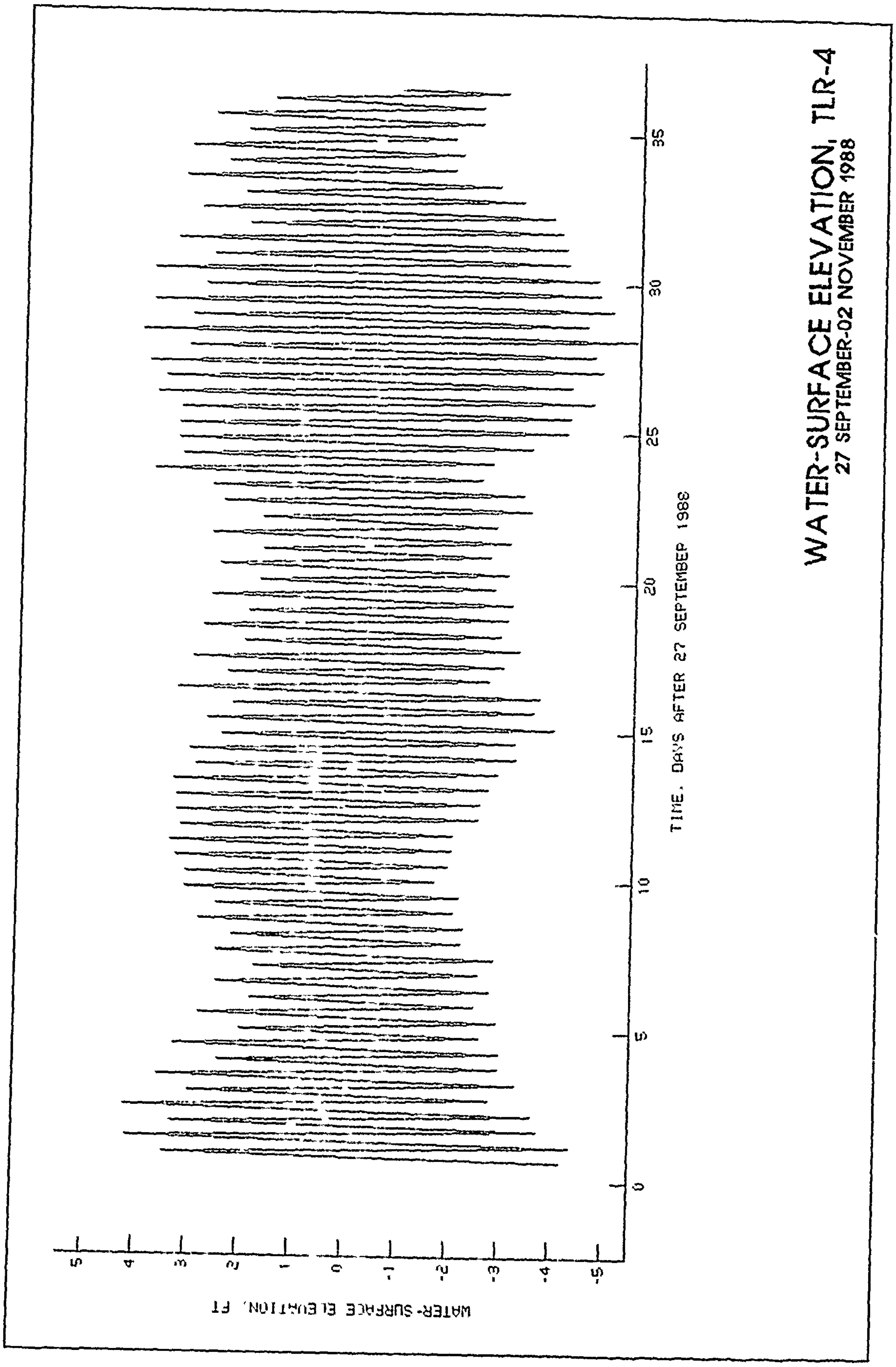

WATER-SURFACE ELEVATION, TLR-4
27 SEPTEMBER-02 NOVEMBER 1988
TIME, DAYS AFTER 27 SEPTEMBER 1988
WATER-SURFACE ELEVATION, FT
0
5
10
15
20
25
30
35
5
4
3
2
1
0
-1
-2
-3
-4
-5

PLATE 19

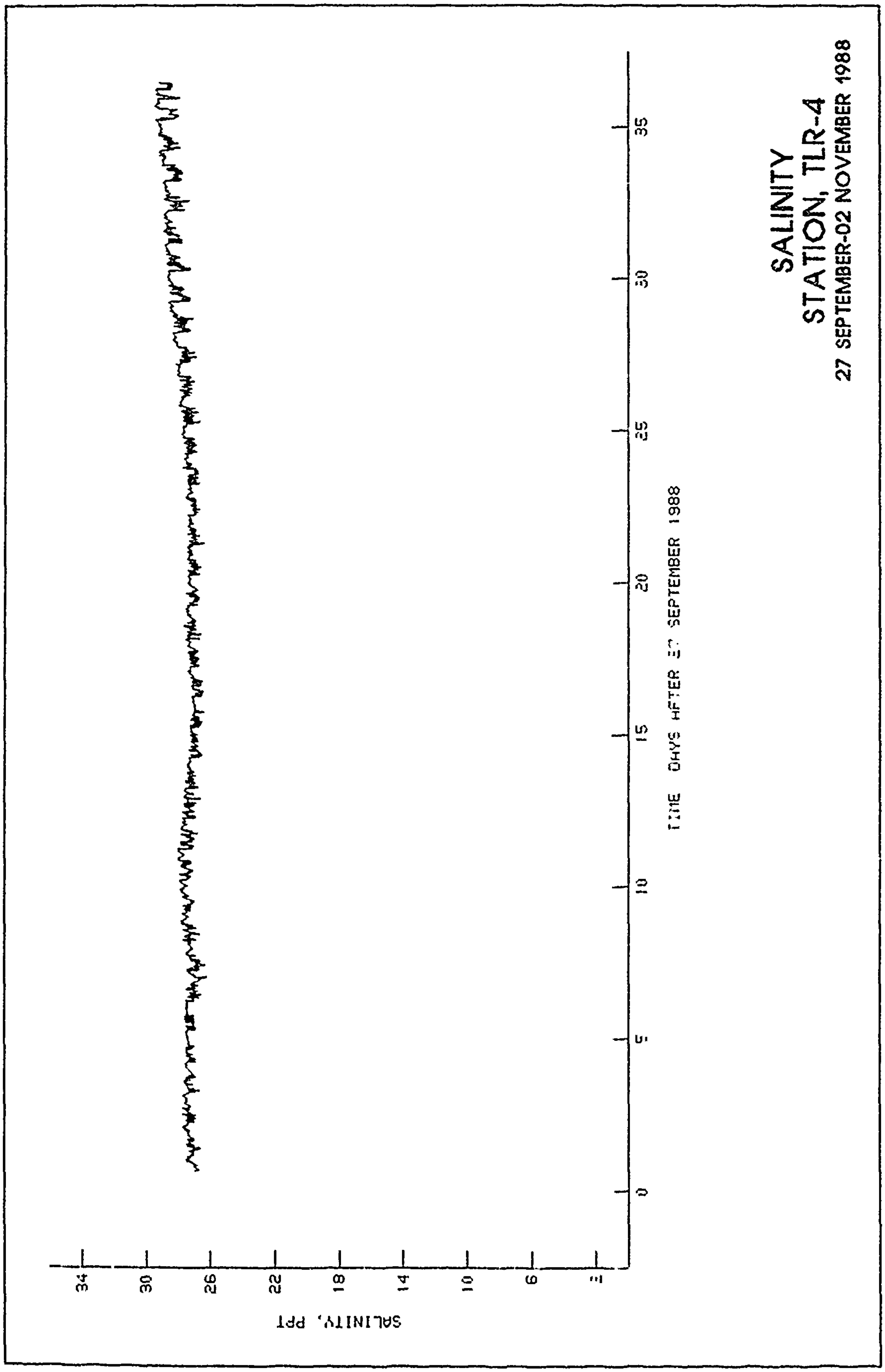
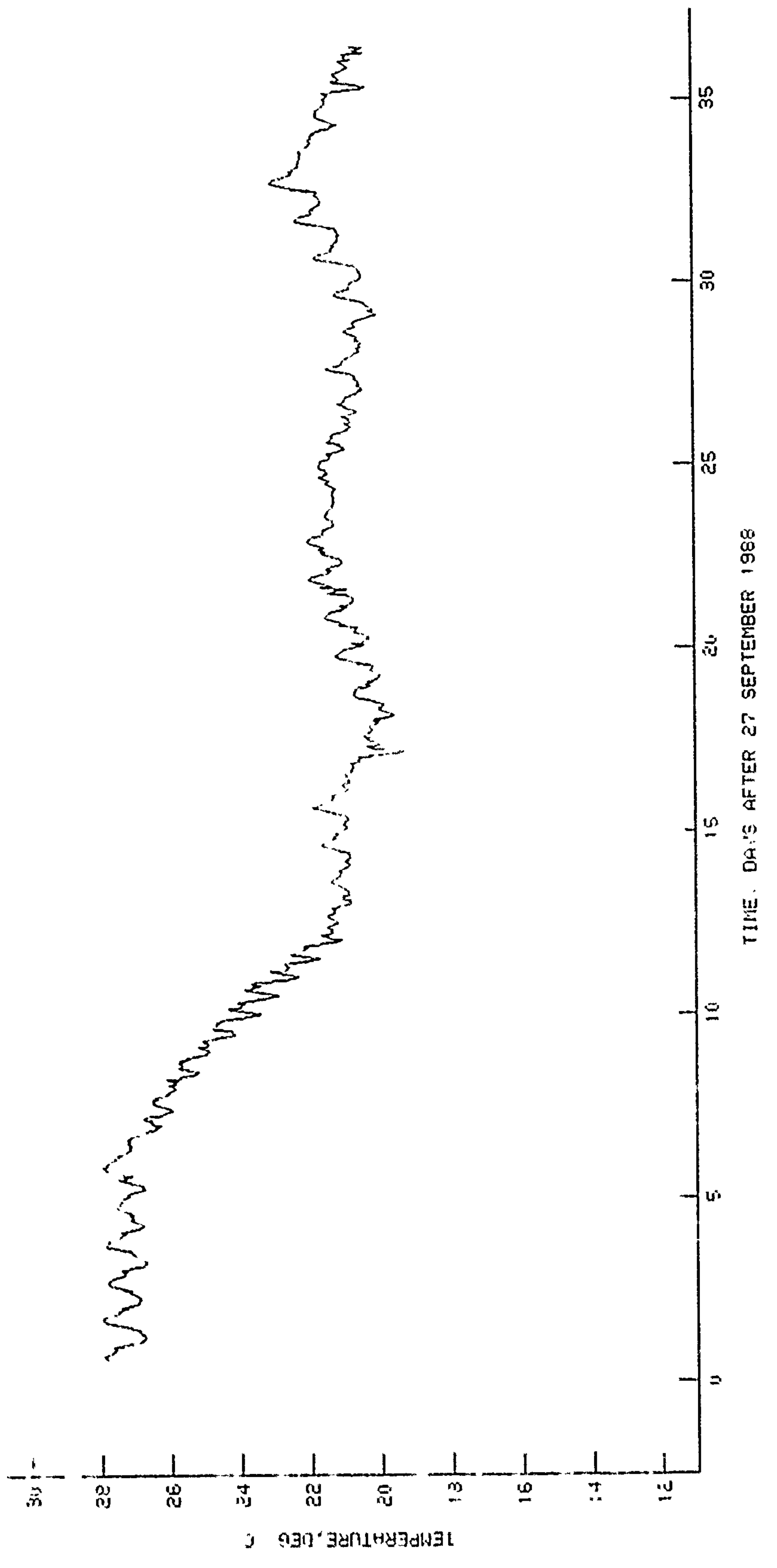
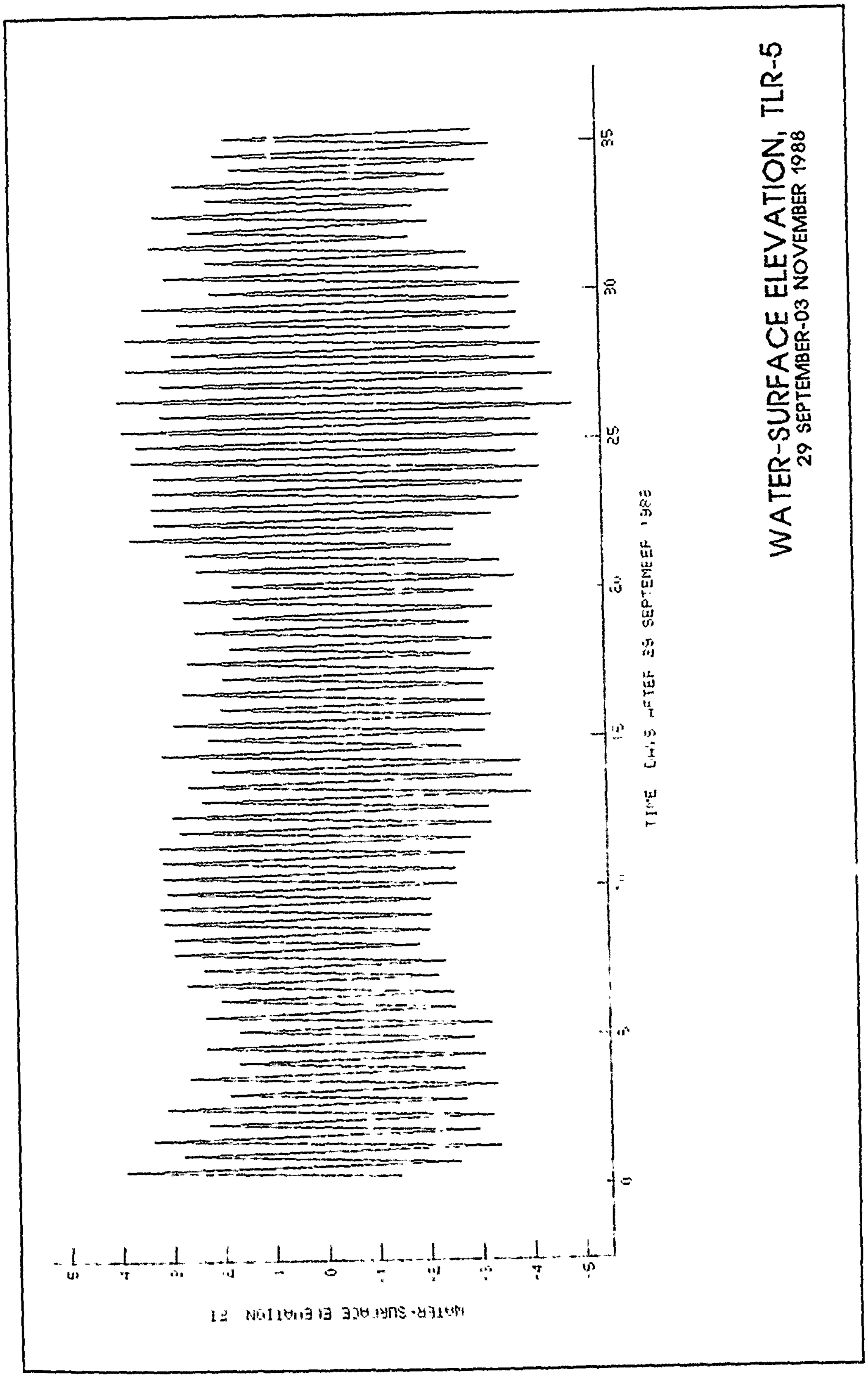

SALINITY
STATION, TLR-4
27 SEPTEMBER-02 NOVEMBER 1988
SALINITY, PPT
34
30
26
22
18
14
10
6
0
5
10
15
20
25
30
35

PLATE 20



TEMPERATURE
STATION, TLR-4
27 SEPTEMBER-02 NOVEMBER 1988

PLATE 21



WATER-SURFACE ELEVATION, TLR-5
29 SEPTEMBER-03 NOVEMBER 1988
TIME DAYS AFTER 29 SEPTEMBER 1988
WATER-SURFACE ELEVATION FT
0
5
15
20
25
30
35

PLATE 22

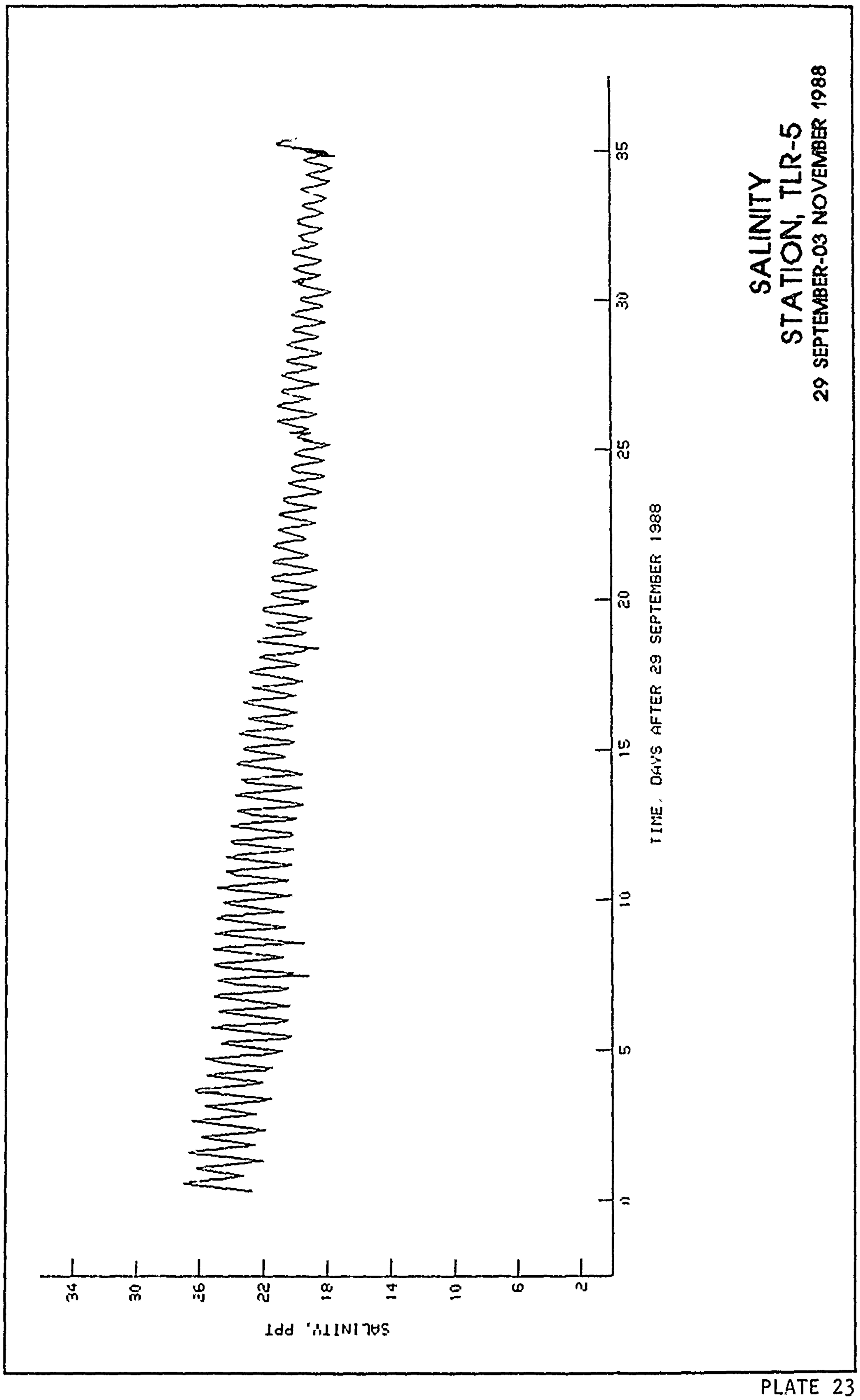

SALINITY
STATION, TLR-5
29 SEPTEMBER-03 NOVEMBER 1988
SALINITY, PPT
34
30
26
22
18
14
10
6
2
0
5
10
15
20
25
30
35
TIME, DAYS AFTER 29 SEPTEMBER 1988

PLATE 23

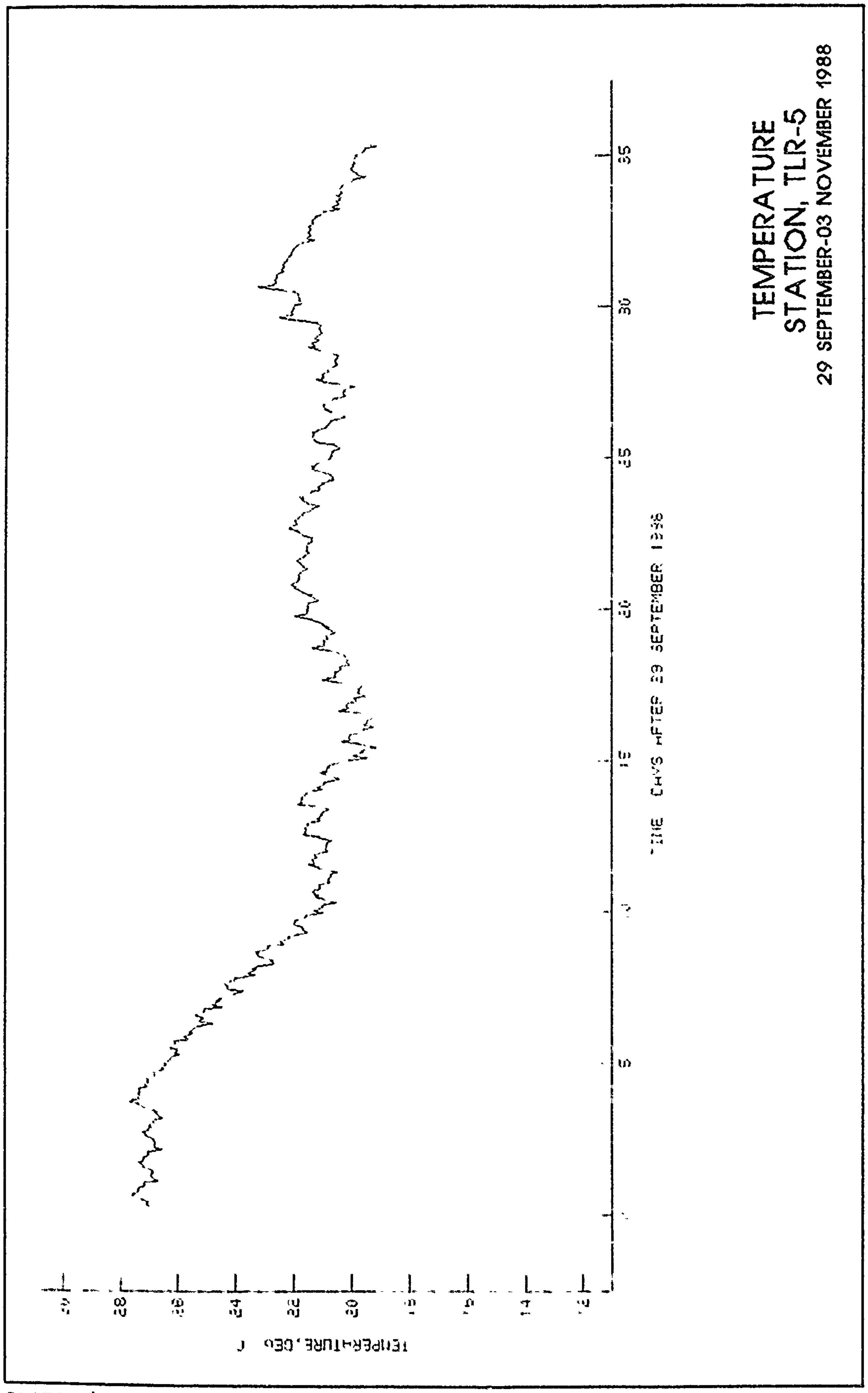
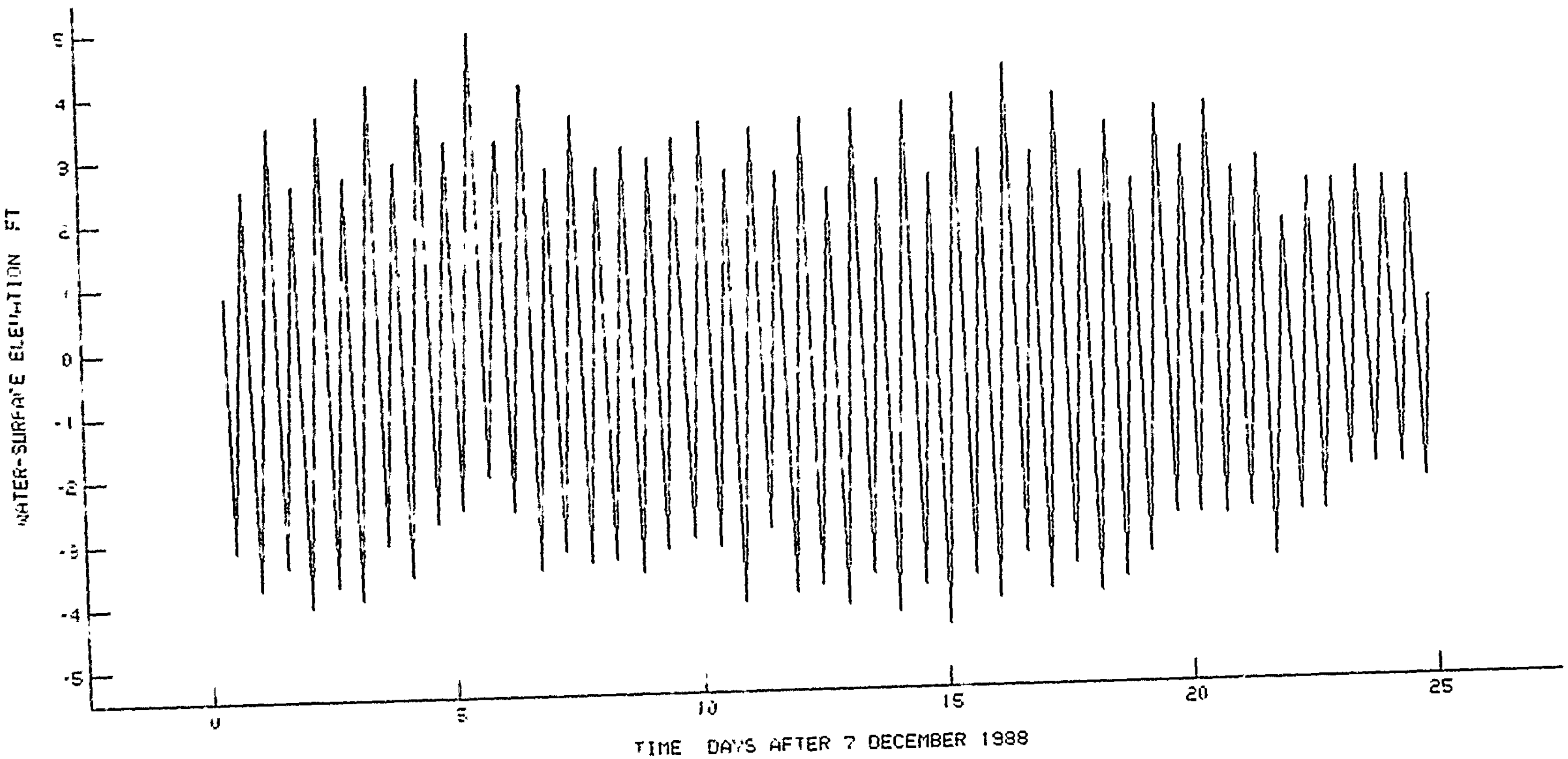
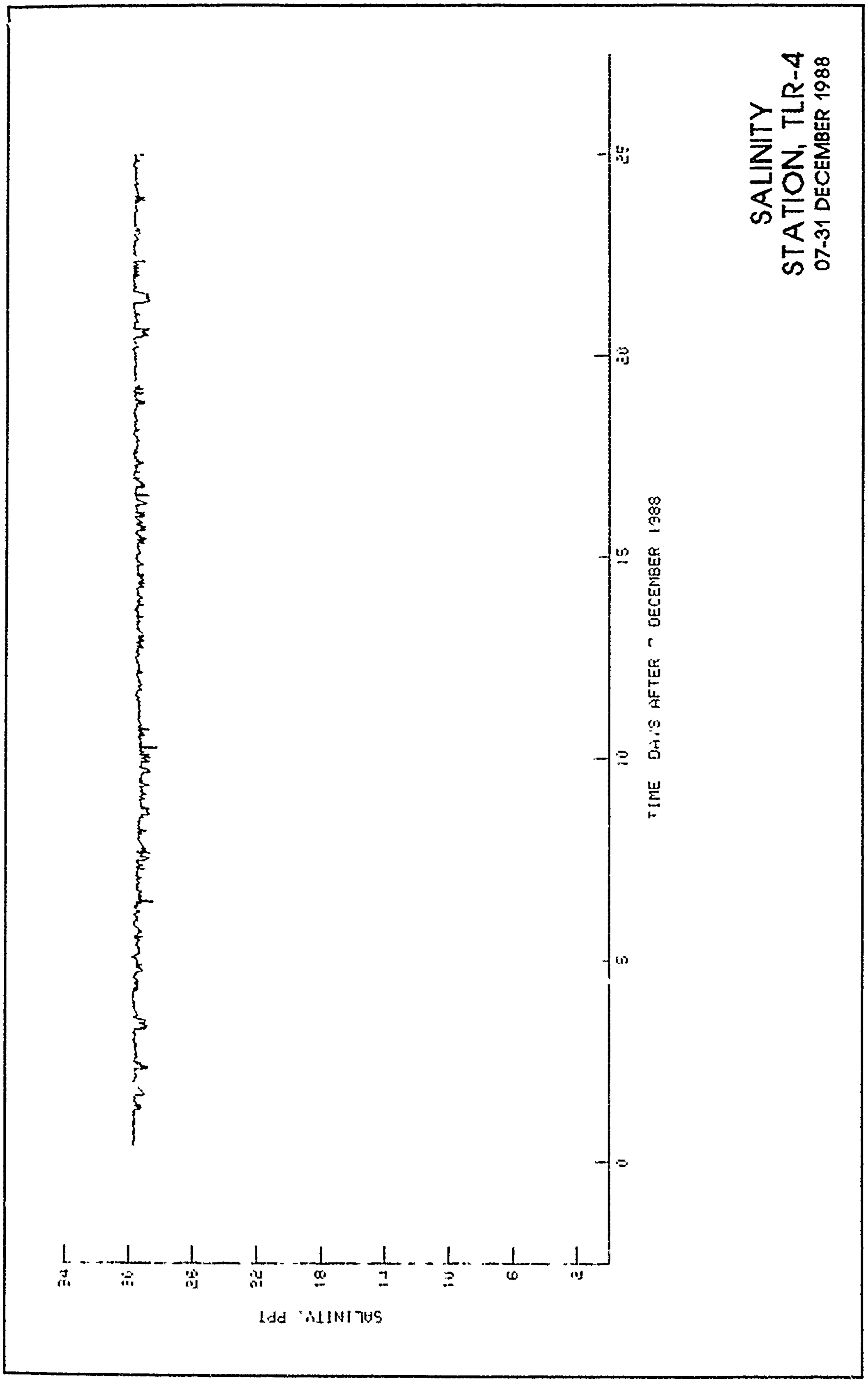

TEMPERATURE
STATION, TLR-5
29 SEPTEMBER-03 NOVEMBER 1988
5
15
20
25
30
35

PLATE 24

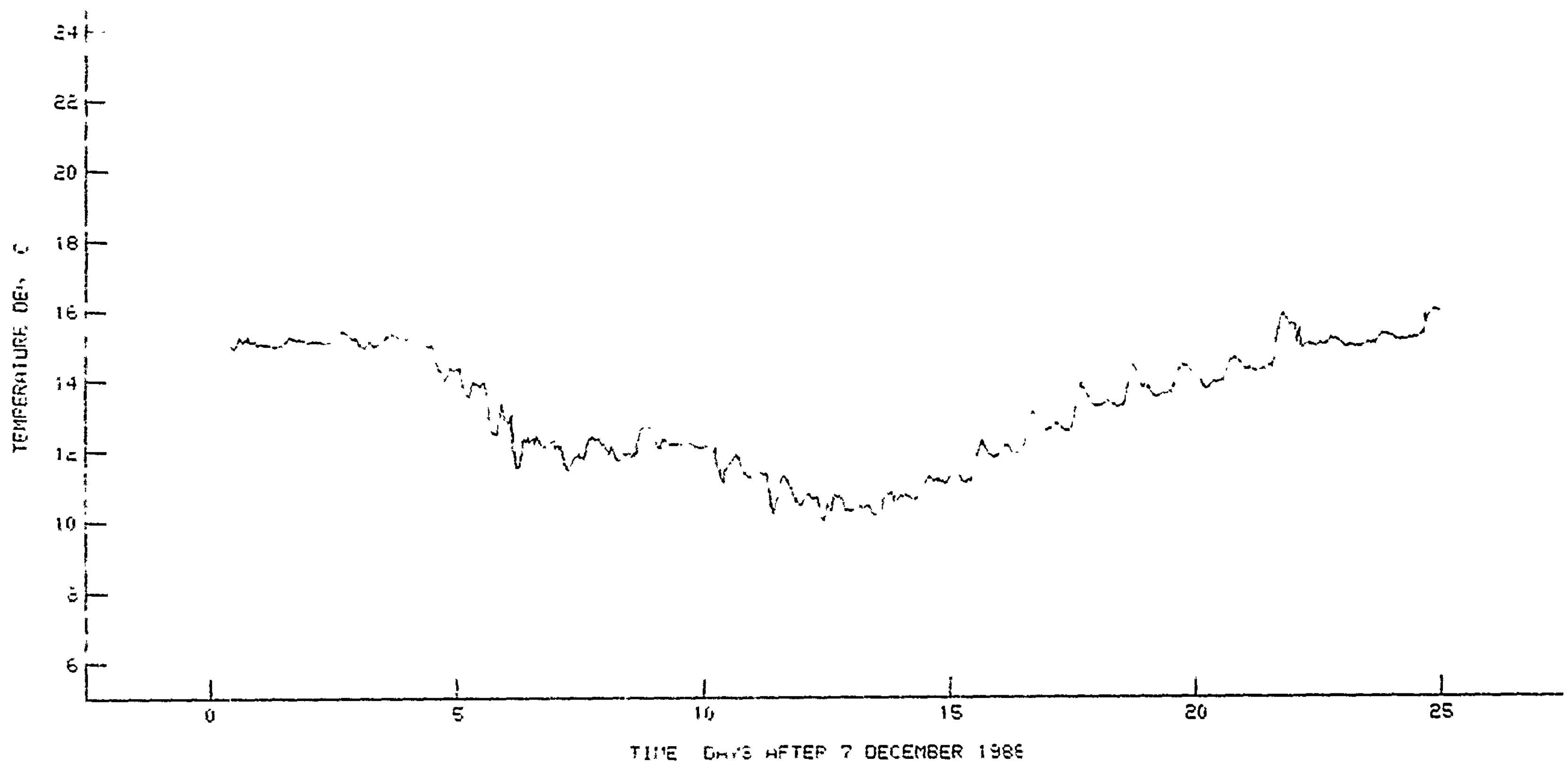


WATER-SURFACE ELEVATION, TLR-4
07-31 DECEMBER 1988



SALINITY
STATION, TLR-4
07-31 DECEMBER 1988
TIME DAYS AFTER 7 DECEMBER 1988
0
5
10
15
20
25
SALINITY, PPT
34
30
26
22
18
14
10
6
2

PLATE 26



TEMPERATURE
STATION, TLR-4
07-31 DECEMBER 1988

PLATE 27

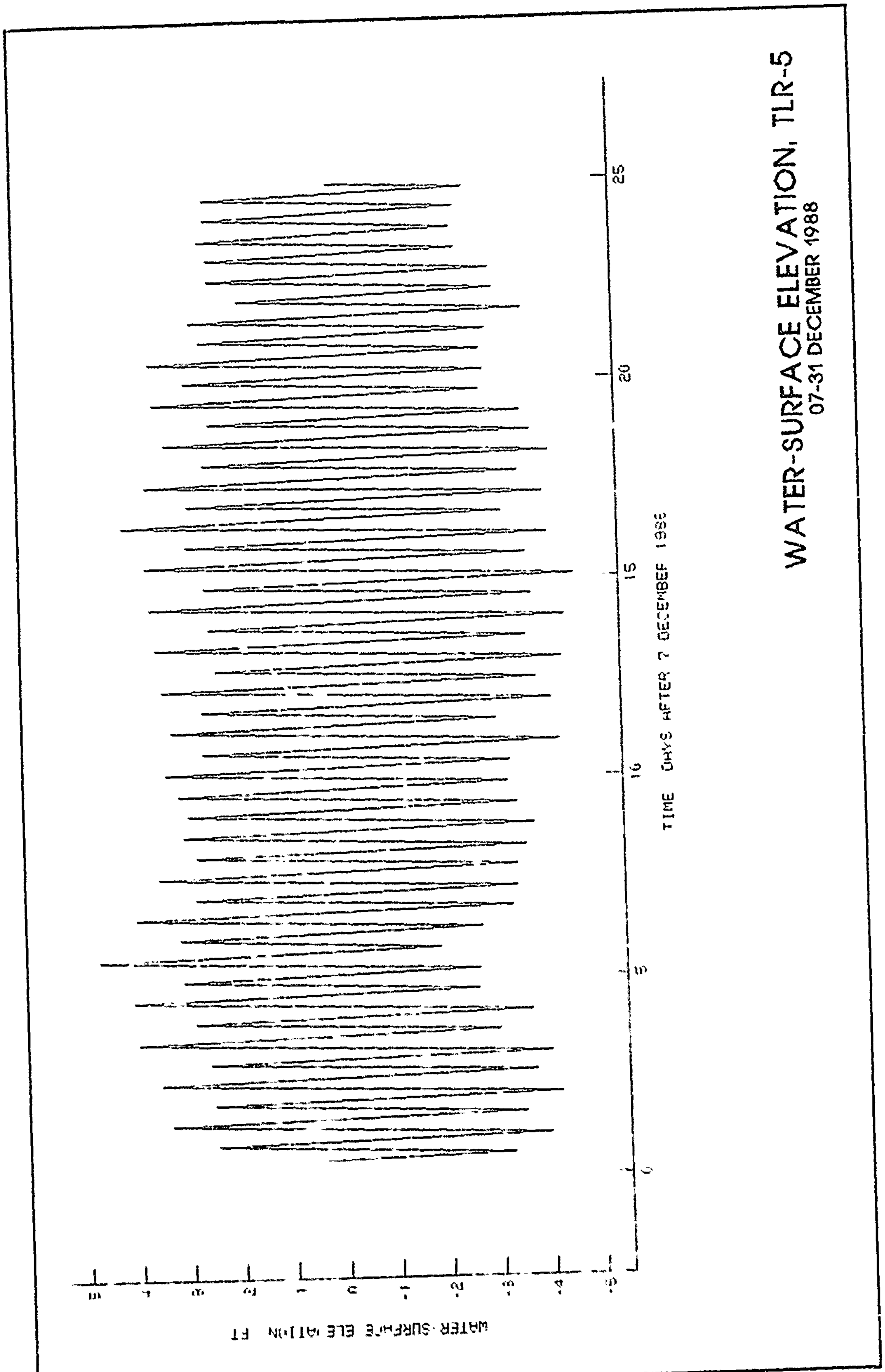
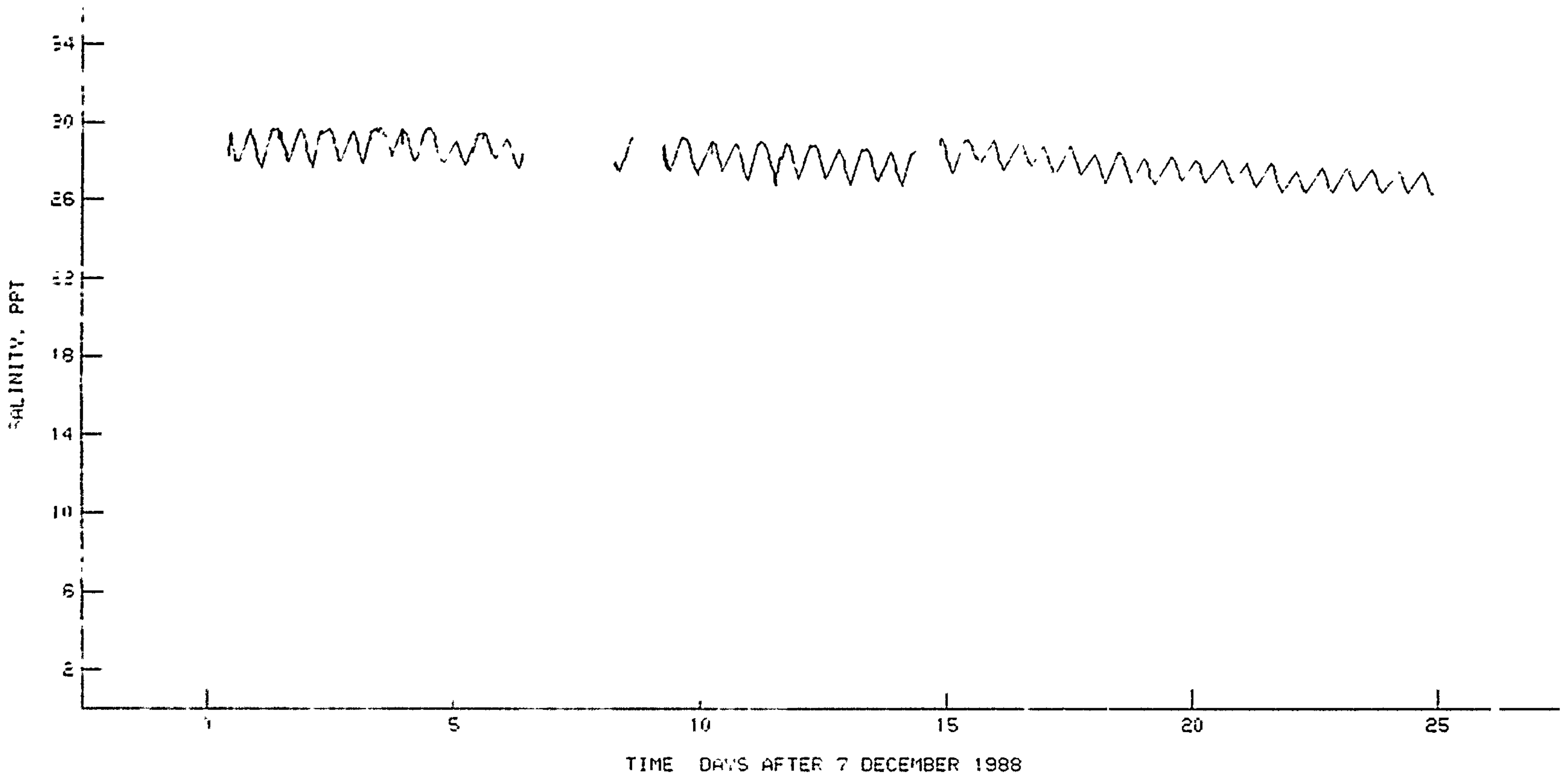

WATER-SURFACE ELEVATION, TLR-5
07-31 DECEMBER 1988
TIME DAYS AFTER 7 DECEMBER 1988
WATER-SURFACE ELEVATION, FT

PLATE 28



SALINITY
STATION, TLR-5
07-31 DECEMBER 1988

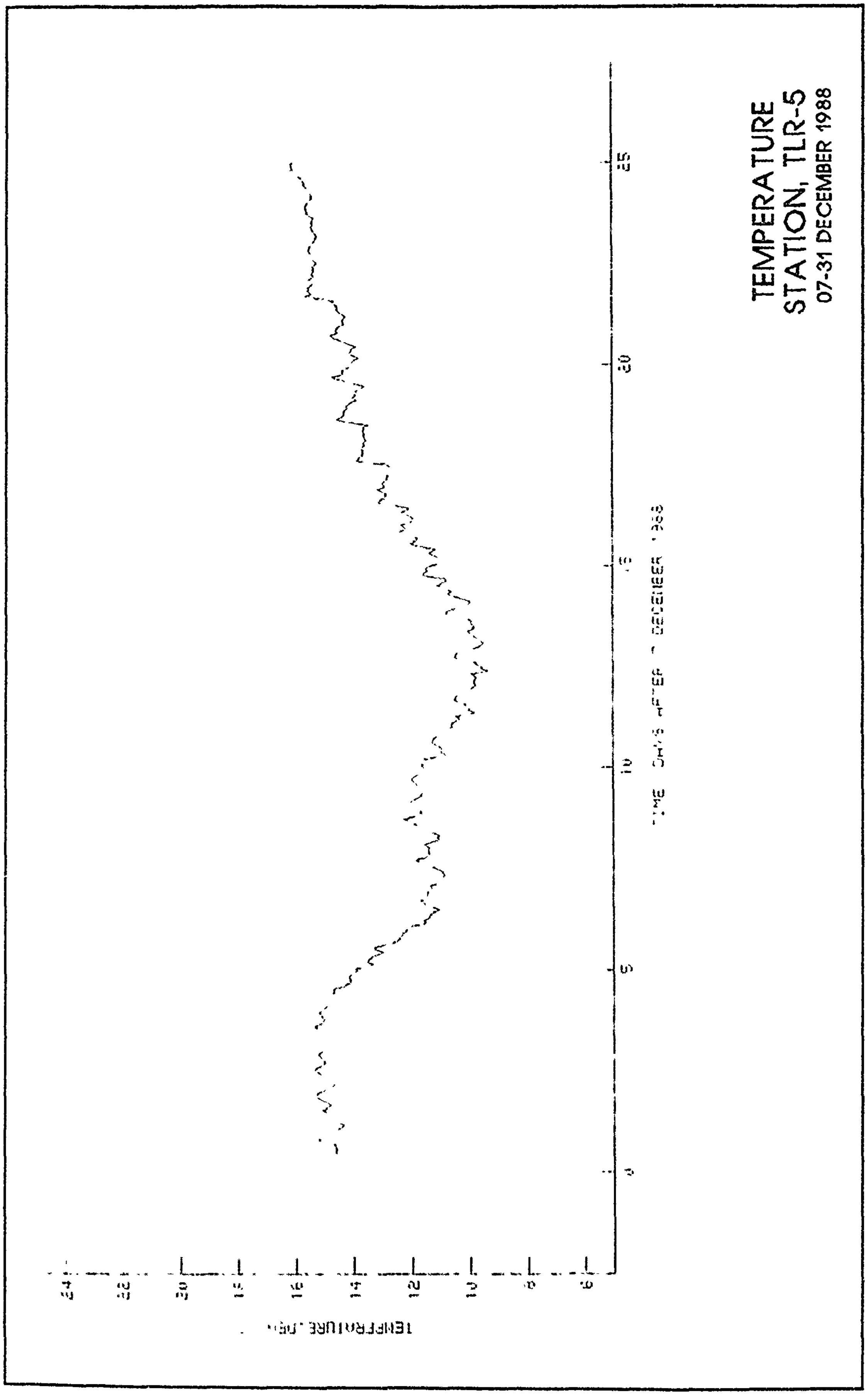


PLATE 30